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USSR Report

EARTH SCIENCES

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METEOROLOGY

AUTOMATED 'LAVINA' COLLECTS DATA ON SNOW

Moscow IZVESTIYA in Russian 28 Aug 84 p 6

[Article by A. Muratov: "The Guard of Mountains"]

[Text] On the slopes of the south-western Tien Shan Mountains, the testing of the "Lavina" automated complex is taking place; it is intended for data gathering in the snowy conditions of the mountains and forecasting natural calamities.

"In order to learn to forecast avalanches, the observer needs to work in the mountains for no less than five years. Only then can he acquire sufficient experience which allows him to correctly judge when and where the roaring mass of snow will rush down the slope," Vladimir Agishev, a senior scientific fellow at the Central Asian Regional Scientific-Research Institute of the Goskomgidromet, said to our correspondent. "As you, of course, understand, the work is not easy and dangerous. Even the most experienced avalanche-observer cannot precisely determine the time when the source that had been accumulating snow discharges--whether it happens during the night or, say, during a blizzard. However, it is very important to know the time: the precision of future forecasts depends on it."

The "Lavina" telemetric system, which has been developed by the workers at our Institute and the Kiev Automation Institute, solved this problem; now, we can learn about the incident with an accuracy of up to one minute. Also, the gages, of which there are 250, provide information regarding snow parameters: the snow cover depth, its surface temperature, etc. All this must be taken into consideration when forecasting an avalanche danger.

The gages are placed at sites where avalanches are most frequent and, of course, where the natural calamaties threaten man: along roads, and in the vicinity of industrial enterprises. The sources at the Chimgan location are taken into account, since every year thousands of downhill skiers come there for a vacation and where, this year, they will hold one of the competitions for the World Cup in this sport.

The information reaches the observational sites, located in the mountains, and from there it is transmitted by radio to the central site of the "Lavina" complex administration, where it is put into a computer. On the basis of the already existing program, the machine rapidly draws a conclusion. From there on, everything is just the way it was: the last word belongs to the export, whose business it is to decide whether this forecast is correct.

[Question] What happens after a forecast is found to be correct?

[Answer] The people are notified, the work in the endangered areas is stopped, and traffic is stopped. In many locations, the method of artificial avalanche release has proven itself. In the Chimgan location we have also tried this method and, it seems, we will be using it. We can determine rather accurately when avalanche danger arises; however, how long it would take from this moment until the avalanche occurs is often very difficult to determine. We cannot risk people's lives. This is why, say, a road is closed immediately, and we wait for the snow to come down. An explosion can provoke even an "unripened" source, which reduces the traffic interruption by an hour, an hour and a half.

[Question] The "Lavina" system makes the work of observers easier. Will it allow them to reduce the number of observational sites?

[Answer] We suppose that there will be no need to create new sites. However, it would have been necessary if only the traditional visual observational methods were available to us. New industrial enterprises and new roads constantly appear in the mountains. Their servicing by systems similar to "Lavina" will, undoubtedly, result in a considerable economic effect.

The "Lavina" complex is a fundamental solution to the information-gathering process, but not restricted to that dealing with snow; by changing gages, one can obtain various data necessary for meteorologists. The tests of the telemetric system have convinced us of its reliability. The "Lavina" gages work for periods not shorter than six months from one supply of energy and provide the observer with information which he used to have to travel several times a day in any weather to gather.

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OCEANOGRAPHY

WEATHER SHIPS 'SHMIDT' AND 'MOLCHANOV' BACK FROM BARENTS SEA

Moscow PRAVDA in Russian 10 Oct 84 p 3

[Article by A. Khramtsov]

[Text] Murmansk, October 9--The weather ships "Professor Molchanov" and "Otto Shmidt" have returned from an expedition to the Barents Sea.

Specialists conducted a complex of scientific research work in line with the program "BAREKS-84" in a northern region of the central trough of the sea. Extensive scientific information was obtained.

FTD/SNAP
CSO: 1865/102

POLAND CONSTRUCTS SOVIET RESEARCH VESSELS

Moscow EKONOMICHESKAYA GAZETA in Russian 3 Aug 84 p 21

[Article: "Vessels from Poland"]

[Text] The Shipbuilding Dock imeni A. Varskiy in Szczecin, Poland gave Soviet clients three scientific research vessels ordered by the USSR Academy of Sciences and several "Neftegaz" series vessels for studying the sea shelf. In 35 years of its existence, the Szczecin dock has built about 180 vessels on the basis of Soviet orders. They are being delivered to our country in accordance with contracts signed between the "Sudoimport" and "Tsentromor," a Polish foreign trade enterprise.

11004
CSO: 1865/75

ADVANCES IN OCEAN MINERAL EXPLORATION

Frunze SOVETSKAYA KIRGIZIYA in Russian 19 Sep 84 p 3

/Article by R. Akhmetov: "A Find Near the Shore of Skeletons"/

/Text/ A scientific search by Moscow scientists has been crowned with an important discovery in the marine geology field. They have discovered a mechanism for forming phosphorites on ocean shelves. On 10 May their substantial treatise was entered into the USSR State Register of Discoveries.

"Phosphorites are sedimentary rocks of sea origin enriched up to 10-15 percent with phosphorus which is approximately one hundred times greater than its usual content in the rocks of the earth's crust," recounts one of the authors of this work Doctor of Geological and Mineralogical Sciences G. N. Baturin. "They are used for chemical industry needs and are especially widely used to produce phosphate fertilizers which are required to make the intensive conduct of agriculture possible."

"Geologists are not of one opinion concerning the origin of phosphorite deposits."

"During the expedition on the scientific research ship "Akademik Kurchatov," I made a find on the Namibian shelf close to the deserted coast which sailors call the "Shore of Skeletons," which forced us to look once again at the origin of phosphorites. Here in the bottom silt I detected soft phosphate formations ranging in size from a grain of sand to a pebble. The mineral was in one of its stages of birth."

"A detailed study of such formations and the bottom silt as well as other factors have led to the discovery of the principles of phosphorite formation."

"This process begins with the help of the wind. Blowing from land, it drives away the upper layers of the coastal current water. Its place is taken by waters, enriched with phosphorus, which come up from the depths. Thanks to the active supply of phosphorus to the upper layers of water which are well heated by the sun, the yield of algae here is a hundred times higher than in the open ocean. The number of sea organisms, fish, and mammals increases sharply on this food base. The abundance in the shelf waters of plants and animals leads to an accumulation on the bottom of deposits, enriched with phosphorus, which sea organisms assimilate during life. These deposits, as a result of geochemical processes, are turned into a phosphate mass resembling jelly and with time--into hard mineral grains."

8524
CSO: 1865/101

'VITYAZ'' SPECIALISTS STUDY HUMAN ADAPTABILITY TO OCEAN DEPTHS

Moscow PRAVDA in Russian 27 Sep 84 p 6

/Article by A. Androshin: "The Depths are Calling--Along with the Researcher"/

/Text/ The deep-water dives in open ocean of the Soviet aquanauts Anatoliy Yurchik, Valeriy Antipov, Nikolay Levchenko, Vladimir Tutubalin, Vladimir Podymov, and their Bulgarian colleague Nikols Dukov have begun with the vivid episodes of the many days of scientific duty which the participants of the combined geological and geophysical expedition performed on board the "Vityaz!"

A depth of 200 meters was reached on one of the dives to the summit of underwater Mount Josephine, located 400 miles west of Gibraltar.

The physiologist Valeriy Skudin, the experienced diver Oleg Kuprikov, staff members of the Institute of Marine Research and Oceanology from Varna Yuriy Dul'skiy and Valentin Tasev, and other specialists belonging to the maintenance provision group are continuously keeping a close eye on the aquanauts.

The testers of the depths were once again able to demonstrate that a person is capable of not only living but also working fruitfully at a substantial distance from the ocean's surface.

"The course under the water is difficult and dangerous," the administrator of the Laboratory of Manned Hyperbaric Systems Oleg Skalatskiy thinks. It is necessary to breath special mixtures in order to successfully reach great depths. If the diver stands in place, he is hot, but when he moves, it is like a cold wind penetrating his body. The return to land takes many hours, until after a set decompression period elapses, whose length often significantly exceeds the time period of the duty on the bottom itself. This is why deep-water descents are possible only by using the so-called long-stay method. Our aquanauts have become the pioneers in their own time in introducing this method into oceanological research practice."

This method, which the aquanauts have mastered, has permitted, for example, Ministry of the Gas Industry specialists to handle depths of about 250 meters in the Barents Sea area.

It is even more difficult in the open ocean. It is hundreds of miles to the nearest shore. Quite often swells are disturbing, rocking even a ship like the "Vityaz'." All kinds of surprises like sharks or deep and narrow cracks in the reefs, which one happens to encounter on the underwater Mount Ampere, lie in wait for the aquanauts on the bottom.

Vladimir Tutubalin, Vladimir Podymov together with the Bulgarian aquanaut Nikola Dukov have excelled on the "Vityaz'," having completed an underwater excursion to the summit of Mount Josephine. It is located at a depth of 200 meters. This dive--and it completed the diving program of the expedition--differed little from the others which were carried out earlier in the Atlantic. Only the day before, the ocean looked implausibly quiet and calm. The lake smooth surface stretched to the horizon. It seemed that a rare success was awaiting the researchers. However, by evening a suspicious breeze began to blow. And in the morning the weather began to deteriorate. Nevertheless, after consulting the weather forecasters, the expedition leaders decided not to postpone the descent.

The aquanauts had been sent beforehand into the ship's pressure chamber where the pressure rose gradually to the necessary mark. Here in the hold of the "Vityaz'" the underwater bell cage was also outfitted for the upcoming trip to the ocean bottom and its cylinders were filled beforehand with a breathing mixture. Incidentally, a computer helped to calculate the mixture's composition for a depth of 200 meters, as well as the descent and subsequent decompression conditions.

The dive of the aquanauts to the 200-meter depth ended the work of the expedition on the underwater Mount Josephine. The crew of the "Rift," which as if it threw a bridge between these heights in the form of deep seismic profiles, also obtained valuable information here.

Sounding the ocean from the side of the ship with powerful acoustical impulses, the group of researchers led by Candidate of Geological and Mineralogical Sciences Vladimir Moskalenko was also able to make deeply hidden structures under the bottom visible.

Telephone communications between the descent and on-board the "Vityaz'" were maintained uninterruptedly by cable. That is why on the ship they knew exactly where the people were, what they were doing, and how they were feeling. A dusky light penetrated to the bottom through the 200-meter thickness of the water, allowing them even to shut off the bell's searchlights. And without them the outcrops of the rocky ridges, next to which the investigators lowered themselves, were quite well distinguished. Leaving their underwater cage, they attentively inspected the summit of Mount Josephine, broke off several bedrock samples, and conducted other observations at the request of the scientists.

When the task was fulfilled, they returned to the ship in the same bell. After docking with the pressure chamber again, they transferred into a dry compartment where they remained until the end of decompression.

Through a small air lock mounted on the body of the pressure chamber, they were handed radiograms from home, books, and an attempt was made to broadcast their favorite songs to them. Even food was individually prepared for them. Delicious cakes were baked for Levchenko, Antipov, and Dukov who celebrated birthdays during their stay under increased pressure.

8524
CSO: 1865/101

MARITIME PROSPECTING, MINING DISCUSSED

Moscow RAZVEDKA I OKHRANA NEDR in Russian No 7, Jul 84 pp 57-60

[Article by Yu. B. Kazmin, USSR Ministry of Geology: "Maritime Geological Prospecting"]

[Text] The world's oceans play an important role as a source of energy and mineral resources. It is enough to say that underwater deposits produce more than 20 percent of the oil output of capitalist and developing countries and this share is steadily growing. Maritime and coastal deposits of tin, gold, diamonds and also titanium also have practical significance. The prospects for mining ferromanganesian nodules, a complex ore with nickel, cobalt, copper and manganese, in deep-water regions of the sea bed have become realistic. Metal-bearing silts and brines and solid sulfide ore indications within the fluted zones of mid-oceanic ridges are showing more and more promise and one can also expect concentrations of gaseous hydrates because of the high hydrostatic pressure and low temperatures at the depths of the oceans.

Our country is also putting a lot of significance on the problem of developing mineral deposits in the world's oceans. Decisions by the 26th CPSU Congress stipulated that the study of the world's oceans, including shelf regions, is one of the the most important issues. Although we have a developed mineral and raw material base that will fill the requirements of the national economy for the significant future, the world's oceans serve as a potential source of mineral raw materials and appropriate measures must be taken so that we have the capability of using them in the future. An extensive program of maritime geological survey work is also necessary because of the development of new international legal norms designed to regulate surveying and developing activity in all areas of the world's oceans. This was prompted by the 1982 adoption of the Law of the Sea which in essence is a code covering all aspects of the use of the sea and its resources and this Convention is expected to become effective in 1986-88.

The Convention established the limits of the continental shelf which includes all of the underwater margins of a continental (continental margins) comprising the geological and geomorphological shelf, the continental slope and the continental foundation. Thus all underwater continental margins totaling an area of approximately 73.6 million kilometers^2 falls under the jurisdiction of the coastal state. Outside this limit, primarily in the

abyssal regions, is the so-called inte national region of the ocean floor and its resources have been declared "the general legacy of man".

Resources in the international area will be prospected and developed only with the permission of the International Agency for the Sea Floor which is to be created immediately after the Convention goes into force and all countries signing the Convention will be members of the International Agency. According to the Convention, access to resources in the international region of the sea floor will be granted only to those states which in the first 20-25 years after the Convention goes into force submit to the International Agency a declaration stating the sea floor areas they desire, begin surveying and developing the deposits within the limits of those areas and develop the corresponding technical means and equipment for deep water mining. A developer mining under contract with the international agency must make a financial allotment to this agency from the time it starts the mining and is also responsible for the technology transfer. The international agency itself will develop resources in the international region along with states and companies and at the end of the 20-25 year period only the Agency will have the right to mine deep-water resources. States that have not been given the right to develop resources in the deep-water regions of the world's oceans by this time will completely lose access to these resources. At the present time, of those mineral resources in the international zone deep-water regions of the world's oceans, ferromanganesian nodules which cover vast areas of the ocean floor at a depth of 4-6 kilometers have practical value. According to various foreign and Soviet estimates their reserves are large and are estimated at millions of tons. However, despite the wide prevalence of these nodules in the world's oceans, industrial ore reserves are limited and the most prospective nodule concentrations have been found in the deep-water regions of the central Pacific Ocean where the Clarion-Clipperton field stands out and also in individual parts of the Indian Ocean.

These nodules have a large number of useful components and of practical interest are the nickel (0.9-1.4 percent), copper (0.5-1.1 percent), cobalt (0.2-0.4 percent) and manganese (25-29 percent). Extensive fields and zones of nodules with deposits densities of 7-10 kilograms per meter^2 and a total copper and nickel content of more that 2 percent have been marked out. Equipment to extract the metals from the nodules has been developed and this allows one to view them as a new perspective type of complex raw material. The U.S., Great Britain, Japan, the FRG, Canada, France and a number of other countries are exploring and prospecting for ferromanganesian nodules in vast regions of the world's oceans and the necessary technical means have been developed for mining 1-3 million dry nodules per year, thus making it profitable. The Soviet Union has been working on ferromanganesian nodules since early the 70's in the Atlantic, Pacific and Indian Oceans. A large degree of geophysical exploration has been accomplished, as have the selection of problems and the study of the nodule's material composition, deep water photography and television surveying of the sea floor, geological engineering and other work. As a result of this work the USSR Mingeo has prepared geological-geophysical and other material which allowed them to compile our country's claim to a portion of the sea floor for the subsequent extraction of ferromanganesian nodules in accordance with the Convention on the Law of the

Sea. In 1983 this claim was submitted by the Yuzhmorgeologiya Association in accordance with the conditions of the International Agency. In 1984 India submitted a like claim for part of the Indian Ocean.

In the near future there will be detailed prospecting and exploration for ferromanganesian nodules. There will also be comprehensive research in the area of the metallurgical processing of nodules and in the technology of mining them. The Yuzhmorgeologiya Association which is to act as the Soviet enterprise in the international region of the sea floor will complete the basic work in ferromanganesian nodules and the association's collective has expended a lot of effort to complete geological prospecting in the ocean floor on time and to develop the technological means necessary for maritime geological survey work.

Specialists of the NIPIokeangeofizik [National Oceanographic Geophysical Research and Design Institute] and the design buro of the association have developed and introduced deep-water photo-, television- and hydroaccustical equipment which allows them to survey the sea floor without interruption and to detect ferromanganesian nodule fields at a sea depth of 5-6 kilometers. The institute's scientists with the successful help of VNR [Hungarian Peoples Republic] specialists have developed a very productive maritime seaborne automated navigational geophysical complex (MARS) and this system has been installed in 19 scientific USSR Mingeo, USSR Academy of Sciences and Mingasprom [Ministry of the Gas Industry] research vessels. With the aid of this equipment we have conducted geophysical and oceanographic studies in practically all regions of the world's oceans and on the shelf of our country and the productivity of maritime work has increased significantly because of the automated control of ships, the collection and processing of information, the increased speed of ships and the around-the-clock observation. The introduction of MARS also allowed a major increase in the depth of the seismic studies and specifically, the structure of the sedimentary depths of the Black Sea was studied to a depth of 14 kilometers from the surface of the floor. In the study of the Barents Sea the sedimentary cover was traced and its structure revealed to a depth of 15 kilometers. The MARS complex as well as other equipment developed by specialists of our industry was highly regarded by specialists not only of our own country but also those abroad and this was proven by responses from representatives to Okeanexpo-80 and Okeanexpo-83 which were held at Bordeaux and where the USSR Mingeo ships Issledovatel' and Morskoy Geolog were demonstrated.

The missions of the USSR Mingeo maritime service is not confined to prospecting for ferromanganesian nodules. No less important and difficult is the work being done by the Sevmorgeologiya Association. While taking part in the ferromanganesian nodule prospecting, the association is doing a significant volume of geological-geophysical exploration in the Arctic Basin. This prospecting is important for evaluating the mineral potential of the Arctic and for establishing the legal limits of the USSR's continental shelf. We must develop enough geological and geophysical information to establish the external limits of the continent's underwater margin.

We have developed a good geological foundation for exploring and prospecting in the Barents-Kara Basin but we must define more exactly the specific lines of geological composition in the sedimentary cover's structural elements that have already been detected, study joint zones and determine their age and genetic relationship. This relates primarily to the joint zones in the South Barents Trough and the Pechorskoye Syncline, in the Southern Kara Synclise along with the contiguous structures of the northern part of the Barents-Kara platform. In the East Arctic Basin we still have to study the geological composition of the sedimentary cover, the relationship of the structures in the Chukchi Sea and the contiguous areas of Alaska and the Beaufort Sea and define more precise the location of the tectonic positions in the internal compositions of the Ust Lensk trough and the Southern Latvian Trough.

Exploration in the Arctic requires that special equipment be developed and this mission is being resolved by scientists and specialists of VNIIOkeangeologiya [All-Union Scientific Research Institute for Oceanographic Geology] and the Murmansk Design Buro which have formed an association. The USSR Mingeo has been conducting a geological-geophysical study of the Antarctic as part of the Soviet Antarctic Expedition since 1956. On the basis of exploration by Sevmorgeologiya geologists, by 1970 the basic features of the Antarctic geological structure had been determined, its tectonic zoning completed, the yield from the earth's crust roughly approximated and a number of useful minerals that had been detected had been investigated. In recent years prospecting has been concentrated in the Weddell Sea area where for the first time a complex of geological-geophysical exploration was carried out on the continent and on the shelf. The seasonal field bases Druzhnaya-1 and Druzhnaya-2 have been operating for many years in the Antarctic and based on material received by Sevmorgeologiya specialists a number of survey maps with the geological content have been prepared and published. In the Prince Charles Mountains in eastern Antarctica Soviet geologists have discovered significant reserves of jaspilite-type ferromanganesian ore and in the future we plan to expand geological-geophysical exploration in the Antarctic. This will obviously require that a permanent geological station be established and special technical means and equipment be developed.

Geological-geophysical prospecting for placers of solid minerals on the USSR continental shelf has provided interesting information. Auriferous and stanniferous provinces and also a number of prospective regions for submarine placers and joints have been established on the Arctic and Far Eastern shelf. American and French discoveries close to the western shores of the American continent of huge concentrations of a new type raw material, massive polymetallic sulfide ore timed to the reef zones of the Eastern Pacific Ocean upheaval which represented an rapidly expanding area of the mid-oceanic range is an example of the inexhaustible riches of the world's oceans. These ores contain a significant amount of zinc, lead, copper, silver and also other rare metals and the information that we have received allows us to suppose that a number of manifestations of these ores may have industrial significance.

In studying the finds of solid sulfide ores in concentration with metal-bearing sediments and brines on the Red Sea bed, one can suppose that the world's oceans are a vast field for researching the metallogenetic process and

for searching for hydrothermal ore signs. The study of sulfide ore traces, the regularity of their distribution and the conditions for their formation and the development of technical means and methods for searching are important tasks for marine geologists. They will be resolved by a complex of geological-geophysical exploration in the reef zones of mid-oceanic ridges that was stipulated by the program for studying the evaluation of the oceanic lithosphere which will be carried out by USSR Mingeo specialists jointly with the USSR Academy of Sciences scientists. The experience of cooperation such as the Anglo-Brazilian geotraverses in the Atlantic Ocean allows us to gather interesting data on the geological composition and history of the region's development, the tectonic and metallogenetic specialization of the earth's crust and the prospects of oil and gas content in the mantle of the Atlantic Ocean's central region.

In the near future we still have to complete prospecting work for the most perspective areas, improve the method of this prospecting and make a comparative geological and economic evaluation of the largest joints of placer formation in the Arctic and the Far Eastern seas. In accordance with the joint decision by the USSR Minister of Geology Ye.A. Kozlovskiy and the President of the Academy of Sciences A.P. Aleksandrov, USSR Mingeo specialists and the USSR Academy of Sciences scientists have prepared a cooperative program for exploring other regions of the world's oceans and for developing various types of geophysical and geological equipment for maritime prospecting.

The USSR Mingeo created a maritime service which unites several thousand specialists. The creation of the association which includes both industrial subdivisions and scientific organizations has allowed the timely development of technical means and significantly reduced the time necessary for them to be introduced. The maritime service is constantly being reinforced with new scientific-technical ships and industrial and dwelling construction is being carried out. In this way a material-technical base which facilitates the resolution of tasks by marine geologists is being developed.

12511
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EXPLORING OCEAN'S MINERAL WEALTH

Moscow NEDELYA in Russian No 33, 13-19 Aug 84 p 7

[Interview with A. S. Monin, director, Institute of Oceanology, by Yu. Samoylov, candidate of Technical Sciences; date and location not given: "From the Seabed"]

> [Text] Mineral deposits: This was perhaps one of the main issues among those discussed at the world's largest forum of geologists--the 27th International Geological Congress, which was held, as we know, in Moscow. Yes, they are becoming increasingly fewer in number on our planet. Especially on land. But enormous riches are locked within the ocean, within its depths. An example is iron-manganese nodules which contain, among other things, extremely scarce materials such as nickel, copper, cobalt and molybdenum. It is no accident that specialists refer to these formations and to sulfide ores discovered recently on the ocean floor as raw material sources of the 21st century.
>
> Today we will discuss a promising direction of this research.

[Question] Almost a hundred years have passed since the time that seamen of the English sailing vessel "Challenger" recovered the first iron-manganese nodules from a bottom sampler raised from the floor of the Pacific Ocean. At that time no one could even have imagined that these unusual "cobblestones" would become an object of meticulous research some time in the future.

[Answer] Yes, the keenness of interest in what you refer to as "cobblestones" was demonstrated by the discussion of the problem at a special session of the congress named "Geology of the World Ocean." A number of reports were presented on this subject by scientists of our institute as well.

We have been able to draw up maps showing the distribution of iron-manganese nodules over the floor of the World Ocean, and to reveal the laws governing change in their composition. We established that it changes depending on the natural zones of the ocean, and particularly depending on climatic zones. There are almost no nodules in the Atlantic Ocean. They are not encountered all that rarely in the Indian Ocean. But their numbers are largest in the Pacific Ocean.

The climate-dependent zones of sediment formation were established for the first time in the ocean by marine geologists of our institute--by USSR Academy of Sciences corresponding members P. L. Bezrukov and A. P. Lisitsyn. They demonstrated for example that along the equator, where plant life develops swiftly and where particles created by vital activities settle very intensively, and consequently where biogenic ooze accumulates quickly on the bottom, there are no nodules at all.

On the other hand nodules cover the bottom like cobblestone walks in waters characterized by low productivity, where accumulation of sediments proceeds extremely slowly (1 millimeter every few millennia). We know of places in the Pacific and Indian oceans where each square meter contains up to 70 kilograms of nodules. Up to 700 tons of this raw material can be collected from a single hectare.

[Question] Are nodules rich in valuable metals wherever they are found?

[Answer] Unfortunately in most cases nodules that are rich in valuable metals do not occur as continuous ore deposits. Only one exception is known at the moment: in the Central Pacific, north of the equator. Intensive research is being conducted here both by Soviet and foreign marine geologists. We conducted a geological survey of a small section of this region back in 1968 under the guidance of P. L. Bezrukov aboard the scientific research vessel "Vityaz'." Later on our geologists performed another three voyages to this area aboard the vessels "Dmitriy Mendeleyev" and "Akademik Mstislav Keldysh." The main objective that we faced was to reveal how nodules form, and why there are many of them in some sections of the floor, and almost none in other areas close by. We need this information so as to make it possible to conduct exploration and prospecting effectively. After all, geologists have never done anything like this before. This is a region of formation of radiolarian ooze--abyssal deposits consisting primarily of the silicon skeletons of unicellular radiolarians. In their lifetime they voraciously absorbed valuable metals from the water, accumulating them in their skeletons.

The result of this research was reported to a congress of our institute's scientists by N. Skornyakova, G. Baturin and I. Murdmaa. I would also like to mention a report given by the American specialists D. Payper and T. Svint, who provided information on the distribution of nodules over the entire floor of the Pacific Ocean. This required them to sample the bottom from scientific vessels at 1500 points!

[Question] Were one to saw a nodule in half, one could see numerous rings around a central core, like the annual rings of a tree trunk. Have you been able to determine how they are formed?

[Answer] Much is still unclear about the origin of nodules. What do we know? We know that nodules formed in tens of thousands of years, layer by layer, on the very surface of abyssal sediments, at the interface between two media--benthic ocean water and ooze. We also understand today why nodules from near the equator are richer in manganese and nonferrous metals: Because organic matter settles to the bottom at a greater rate, conditions permitting additional accumulation of manganese and, possibly, nonferrous metals as well, from

the bottom, from benthic deposits, are created. Manganese hydroxides are exceptionally good at "extracting" copper, nickel and some other substances from highly diluted solutions. This is why the manganese-enriched orelike substance in nodules absorbs more nonferrous metals, forming rich ore in the equatorial zone. The orelike material accumulated in this way, layer by layer. In our opinion electrochemical processes played the main role in this.

There is one other riddle: Why does the bulk of the matter of the nodules lie on the surface of the bottom, rather than being blanketed by ooze? It would be simplest of all to hypothesize that they formed after accumulation of ooze. But radio isotope analysis revealed that the age of the ooze is often but a few tens of thousands of years, while the age of nodules is reckoned in the hundreds or even millions of years. Thus it turns out that nodules are older than the sediments beneath them. It was virtually as if someone or something pushed them to the surface of the "young" liquid ooze and kept them "afloat", while sediments continued to accumulate, invading the space beneath them. Numerous different hypotheses have been stated to explain this phenomenon. As an example it was proposed that nodules are pushed out from the ooze by benthic animals. But it would hardly be sensible to heap the enormous burden of turning and pushing out billions of tons of nodules upon puny invertebrates inhabiting conditions that are unfavorable as it is. They would never have been able to manage such a burden. The hypothesis that the nodules float up in response to the action of the elastic properties of the ooze itself seems much more probable. According to this hypothesis the elasticity of the thin upper layer of settling ooze differs little from the properties of a liquid. But over the years, the ooze grows denser. Water is displaced from it, and the moment comes when its properties begin to recall more those of rubber than a liquid. A ball immersed into such a medium is essentially pushed up by elastic forces. Calculations made with regard for the parameters of marine ooze showed that nodules of any shape can be pushed out, even if they are "buried" by ooze to more than half their height.

[Question] How profitable do you think it would be to mine iron-manganese nodules?

[Answer] Ten or 15 years ago the mining of such ore was thought to be unpromising. First of all it was believed that it is too poor in valuable metals, second, they do not lie close together on the bottom, and third, it is too difficult to extract them from a depth of 5 kilometers, where most of them occur. But opinions on mining iron-manganese nodules have begun to change in connection with depletion of the reserves of valuable metals. According to our estimates there are on the order of 2 or 3 trillion tons of such nodules on the floor of the World Ocean. Various mining schemes are being discussed today in the world. We are studying the most favorable regions for mining iron-manganese nodules. Thus this is no longer a matter for the distant future.

Incidentally, in addition to nodules, iron-manganese crusts can be encountered on the ocean floor, covering rock in areas of mid-oceanic ridges. These crusts are often located 1-3 kilometers deep. It was found that they contain more manganese than do nodules. Their origin is probably different as well.

Both Soviet and foreign oceanologists tend to believe that these crusts are formed by deposition of metals from hydrothermal springs flowing from the ocean floor. Outwardly they recall terrestrial geysers, but the flowing substance is black. Because of their unusual color, oceanologists observing them from the portholes of manned submersibles named them black smokers. They form not only iron-manganese crusts but also other sulfide ores of zinc, copper, cobalt and other metals. The English scientist S. G. Wakefield presented some conclusions on the nature of these ores in his report, "Abyssal Metal Containing Sediments: What Is Their Significance?" He believes that these ores are only one of the links in a continuous chain of different types of oceanic sediments. We support his point of view.

[Question] Sulfide ores have also been attracting the attention of oceanologists recently. Can we anticipate that sulfide ores will become an object of industrial mining?

[Answer] With the help of scientific research vessels we discovered high-temperature sulfide minerals in rock and sediments of the central ridges of the Indian Ocean in the 1960s. Soon after, foreign researchers also found sulfide ores in rift zones of the Pacific Ocean south of the Gulf of California. Such ore was located at places of emergence of hot springs from the floor. They were found to be rich in copper, zinc and some other valuable metals. It is not yet entirely clear as to whether such ore is abundant in the ocean, and as to whether it will become an object of wide industrial mining. But in principle we can anticipate their presence in the entire system of mid-oceanic ridges, the total length of which is about 60,000 kilometers. In general, we were once again persuaded in this congress that marine geology has opened up a new, vast metal containing province on earth--the floor of the World Ocean.

11004
CSO: 1865/77

NEW CATAMARAN 'GEOLOG PRIMOR'YA' USED TO STUDY OCEAN DEPTHS

Moscow SOVETSKAYA ROSSIYA in Russian 13 May 84 p 2

[Interview with Yu. A. Podgoretskiy, of the RSFSR Ministry of Geology, by Z. Safonova, date and place not given: "'Geolog' Sets Out for the Ocean"]

[Text] The catamaran "Geolog Primor'ya", a new vessel, successfully completed its trials in coastal waters of the Pacific Ocean, and the commission has accepted it for operation with an excellent score.

We asked Yu. A. Podgoretskiy, deputy chairman of the acceptance commission and chief process engineer of the division of marine geological exploration of the RSFSR Ministry of Geology, to describe this event.

[Answer] Marine geologists never had such a vessel before. It is a specialized drilling vessel capable of searching for solid mineral deposits and of conducting engineering and geological explorations in shallow waters of the sea shelf. Drilling operations can be conducted right from the deck to a water depth of 50 meters and just as deep into the seabed.

The catamaran is quite a beauty! Its design is unusual: Two paired vessels are joined together by a single deck. Owing to this it has good stability, and work can proceed routinely aboard it in a three-point sea state. It would not even rock. During drilling, it is firmly secured by four anchors.

[Question] Yuriy Aleksandrovich, please take us on an armchair tour of the vessel.

[Answer] Let us begin with the drilling rig. It is located at the stern. The deck is so large that all of the equipment fits without crowding. The ship also has its own laboratory, where specialists can study a core raised from the seabed right on the spot. A special steering unit locates the catamaran at a prescribed drilling point. Comfortable, well-equipped cabins have been prepared for the marine geologists, and the vessel has a television set, a stereo system and a spacious dining room.

[Question] What are the advantages of the new vessel?

[Answer] According to estimates made by the Central Scientific Research Institute imeni A. N. Krylov the outlays on drilling a linear meter from the

catamaran are one and a half to three times lower than the cost with existing watercraft.

Primorskiiy Kray's Territorial Geological Administration, which has the job of exploring mineral deposits, has floating drilling rigs such as the "Amur" and "Primorets" in its possession, but their technical characteristics limit mineral exploration only to water basins sheltered from wind and waves. The catamaran can conduct geological explorations and drilling operations along the entire shallow-water zone of the Far East, including remote open water basins characterized by complex weather conditions.

Good navigation qualities, the possibility for independent sailing without escort vessels, and moreover, a perfected drilling rig exhibiting higher productivity are advantages of the catamaran that were noted in due fashion by the specialists.

The Far East coast is still poorly studied, and the "Geolog Primor'ya" has a lot of work to do. Now that the trials have been completed successfully, the discussion will turn to building a series of new catamarans for exploring the seabed.

There remains to be added that the plan for the vessel was drawn up on the basis of an assignment from geologists of the Primorgeologiya Association. It was built in Vladivostok at the Far East Plant imeni 50-letiye SSSR.

11004
CSO: 1865/75

'AKADEMIK KURCHATOV' EXPEDITION STUDIES GULF STREAM NORTH OF BERMUDA

Moscow PRAVDA in Russian 28 Jul 84 p 3

[Article: "The Gulf Stream in 'Cross Section'"]

[Text] 25 July, Wednesday. The results of a hydrological expedition by the Institute of Oceanology of the USSR Academy of Sciences are summarized.

The water carried a strong odor of algae on that day. It was stormy. Cold salty spray swept over the ship. The scientific research vessel "Akademik Kurchatov" was entering a cyclone area. The Bermudas were left behind to the south. And here, in the active-energy zone of the Gulf Stream, members of the hydrological expedition of the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, had to conduct research and experiments of the "Cross Sections" program.

"This program may provide answers to many questions on short-period changes in climate taking from one or two seasons to one or two years to occur," said the leader of this expedition, Yuriy Aleksandrovich Shishkov, the institute's senior scientist.

Echo soundings were quickly made of the bottom topography in order to determine the optimum point at which to take measurements. Not long after, a hydrophysical probe was lowered into the water on a cable. There were apprehensions: It is no joke lowering a unique electronic instrument weighing 20 kilograms into a stormy ocean. The probe contained sensors measuring the temperature of the ocean water, its conductivity and pressure. The data are transmitted to a microcomputer, in which they are decoded. And then the conductivity readings are used to determine salinity while pressure readings are used to determine the depth of the instrument at this point in the Atlantic.

The scientific group from the Institute of Oceanology imeni P. P. Shirshov of the USSR Academy of Sciences and the vessel crew worked almost around the clock for three months. Moreover the expedition was being carried out at a time when cyclones were constantly forming in the Gulf Stream, and strong winds were blowing. Hydrophysical research is not enough for compiling a map of the thermal and energetic state of the Gulf Stream. This is why aerological and meteorological measurements were conducted from aboard the "Akademik Kurchatov".

This is not the first year in which the Gulf Stream has been studied by Soviet scientists. Numerous data have been accumulated on the periodicity of climatic changes. Can any conclusions be made today on what the weather will be like in the immediate future?

"Yes, large amounts of data are available," said Yuriy Aleksandrovich. "But it is a very difficult thing to organize them in such a way as to arrive at a conclusion. Our scientists would not even risk assuming a strictly definite position on the scientific question which has now long been under debate--our planet's gradual cooling or warming. There are too many things that can be said pro and con. Moreover their immediate tasks are more modest: Their job is to 'guess' what the weather would be like a maximum of half a year into the future. Incidentally, they did predict the heat wave that occurred at the beginning of this summer."

11004

CSO: 1865/75

RESEARCH VESSELS RETURN FROM PACIFIC MINERAL EXPLORATION

Moscow VODNYY TRANSPORT in Russian 23 Aug 84 p 4

[Article by O. Avdeyev]

[Text] The scientific research vessels of the production association, "Southern Seas Geology," are conducting a large scientific operation in the waters of the World Ocean. The comprehensive group expedition returned to the home port of Gelendzhik under the association flagship, the scientific research vessel, "17th Congress of Trade Unions." For more than 10 months (312 days) the vessel has plowed the waters of the central section of the Pacific Ocean, where the geological-geophysical operations on the study of resources of the World Ocean were carried out. The participants of the expedition (directed by V. Lebedev) and the vessel crew (headed by Captain B. Omel'yantsev) accomplished the great volume of work with honor.

12318
CSO: 1865/76

MINERAL EXPLORATION ON ATLANTIC BOTTOM

Baku VYSHKA in Russian 4 Aug 84 p 4

[Interview with Kh. Aliyulla, doctor of Geological and Mineralogical Sciences, by Ad. Aliyev, date and place not given]

[Excerpt In recent years the problem of studying the World Ocean, which occupies 70 percent of the entire territory of the Earth, has taken on particularly important significance. The ocean and sea bottom is truly an untouched storehouse of mineral wealth. Here, deposits of iron manganese, phosphorite concretions and a number of valuable metals have been discovered. More than 70 chemical elements of Mendeleyev's periodic system are contained in ocean water. The coastal (shelf) sections of the World Ocean contain oil and gas.

Over the course of a number of years Azerbaijan scientists have participated in the comprehensive research. They have ploughed the wide open expanse of the Pacific, Indian and Atlantic Oceans on the scientific research vessels "Vityaz'," "Persey," "Akademik Vernadskiy" and "Akademik Kurchatov." Recently, Khalil Aliyulla, doctor of geological and mineralogocial sciences and director of a laboratory of the Azerbaijan SSR Academy of Sciences Geology Institute, returned from a routine ocean expedition. Over the course of three and a half months the scientists, as a part of a comprehensive USSR Academy of Sciences expedition, conducted research on the central section of the Atlantic Ocean.

We have requested Khalil Aliyulla to answer a number of questions relating to this expedition.

[Question] What was the goal of the Atlantic expedition, and above all, what geological research has been accomplished?

[Answer] During the present stage of geological research, a comprehensive study of the World Ocean is being done in order to solve a number of problems concerning the structure of the ocean bottom, continental drift, volcanic processes, zoogeography and many other questions, and, of course, to study and master the ocean's natural resources. A great deal of work is also being done on problems of geology, biology, hydrology, hydrophysics and chemistry of the ocean.

In the Soviet Union ocean research is done on a broad basis by the USSR Academy of Sciences Oceanology Institute imeni P.P. Shirshov. This ocean expedition was conducted on the scientific research vessel, "Akademik Kurchatov," and was devoted to the study of the central section of the Atlantic. Seventy scientists, primarily from the Oceanology Institute (but from the scientific centers of Baku, Vladivostok, Khabarovsk, Kaliningrad and Rostov as well) participated in this expedition. In the Caribbean basin, Cuban specialists joined us. They were interested in hydrological questions of the deep Cayman trench, located between Cuba and the island of Jamaica.

During the voyage on the scientific research ship, "Akademik Kurchatov" geological operations were carried out in the Atlantic tropical zone, along 22° north latitude. The geological research undertaken on the transatlantic profile encompassed various ocean depths.

During comprehensive geological operations lithological, stratigraphic, paleomagnetic, geochemical and geomorphological operations were completed.

12318
CSO: 1865/76

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HYDROLOGIC CHARACTERISTICS OF THE MEDITERRANEAN AND BLACK SEA

Kiev VISNYK AKADEMIYI NAUK UKRAYINS'KOYI RSR in Ukrainian No 4, Apr 84
pp 79-84

[Article published under the heading "Expeditions," by Candidate of Technical Sciences M.G. Perov, Yu.S. Kalashnikova, N.Ya. Kuklina, and I.F. Lukashin: "Hydrologic Characteristics of the Mediterranean and Black Sea: Results of Field Investigations On the Fifth Voyage (Second Phase) of the Research Vessel 'Professor Kolesnikov'"]

[Text] The second phase of field investigations on the fifth voyage of the research vessel "Professor Kolesnikov" took place in winter (January-February 1983) in the Mediterranean (field areas 2 and 3) and in the western part of the Black Sea (Field Area 1--Figure 1).

The principal objective was to investigate space-time variability of hydrologic characteristics of the test areas on a microscale and mesoscale, as well as background parameter data on the selected areas of the Mediterranean in order to study the radiochemical behavior of specific radionuclides in the process of transport and diffusion of a passive admixture in the sea medium.

Measurements of the hydrologic characteristics of vertical distribution of the stratified structure of hydrophysical fields on a microscale were accomplished with the aid of a high-speed sensing package developed in the Experimental Department at MHI [Marine Hydrophysical Institute] [1].

During the period of observations the hydrologic picture in the Black Sea Field Area has been characterized by virtually total isothermy of the surface mass to a depth of 50-60 m. The temperature of this layer fluctuated around 9 degrees Centigrade. The temperature gradient at the boundary with the cold layer is fairly substantial--0.8 degrees/m. In contrast to the sharply-defined upper boundary of the cold intermediate layer, its lower boundary was diffuse, and it was impossible to determine it unequivocally (Figure 2). For this period of observations such a state is quite understandable, since the previous year's cold layer was close to total breakdown, while the layer of the winter of 1982-1983 had remained in a state of development due to the abnormally warm weather at the commencement of winter.

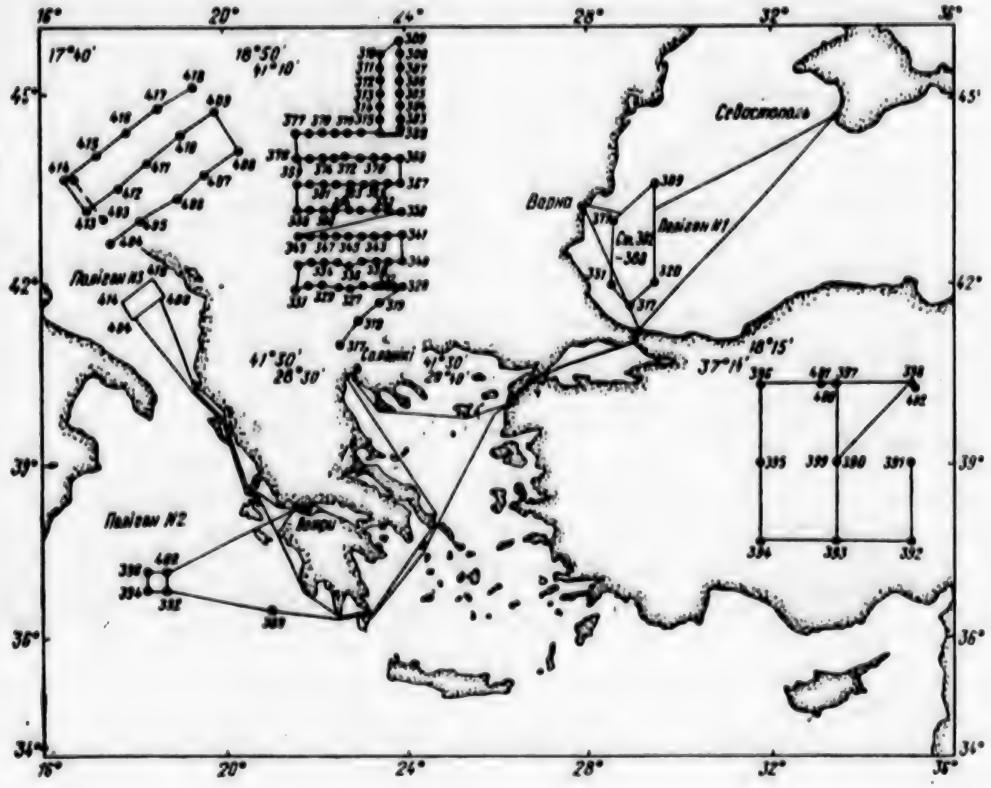

Figure 1. Route of field investigations of research vessel "Professor Kolesnikov."

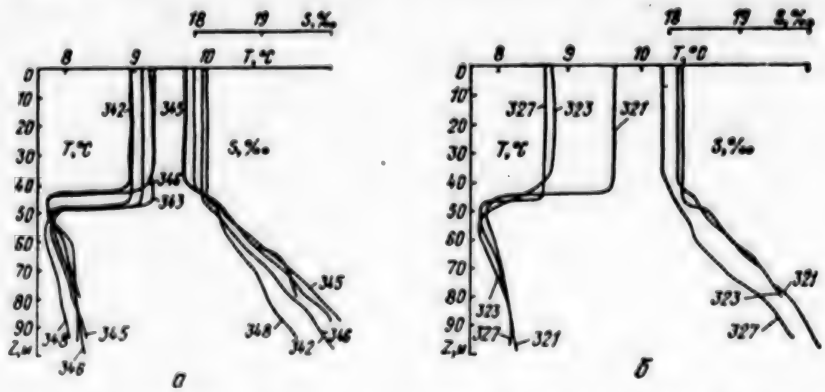

Figure 2. Vertical distribution of temperature and salinity in Field Area 1: a--stations 342, 343, 345, 346, 348; b--stations 321, 323, 327.

At the near-shore stations of the field area one observed an increase in thickness of the cold intermediate layer, connected with the rise of deep, colder waters to the surface along the continental slope and their mixing with the cold intermediate layer.

From sensing data on horizontal temperature distributions in the Black Sea field area, one could trace the existence of frontal zones created by transformation of the northern surface cold mass (below 9 degrees Centigrade)

in a southerly direction along the isobaths of the continental slope (Figure 3). During observations in the test area, the flow of the northern cold mass was broken up by a strong westerly wind blowing at an average velocity of 10-12 m/s; therefore in the center of the test area there was a coastal water mass with a temperature above 9.2 degrees Centigrade. The western part of the test area was characterized by a water mass with a temperature above 9.5 degrees Centigrade, which corresponds to the open part of the Black Sea basin, where the cooling influence of the land is weakened.

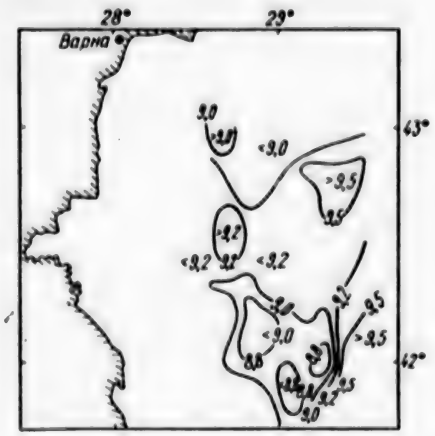

Figure 3. Horizontal distribution of temperature on the surface of Field Area 1.

According to the data of hydrophysical investigations of the field area in the central part of the Mediterranean (Field Area 2), in winter isothermy was observed to depths of 120-140 m with a temperature of 15.8 degrees Centigrade and salinity of 38.25°/00. In this layer the vertical temperature distribution gradients did not exceed 0.015 degrees/m, and salinity gradients--0.02°/00 m.

Below this layer temperature dropped off smoothly to depths of 450-500 m, reaching 13.9 degrees Celsius with a salinity of 38.9°/00. At the upper boundary of the layer maximum values of vertical temperature gradients were 0.14 degrees/m, and salinity--0.09 °/00 per meter. Beginning at a depth of 500 m, temperature and salinity remained virtually unchanged, with an average fluctuation of 0.005 degrees/m in temperature and 0.003 °/00 per meter in salinity.

The time variability of temperature, salinity, and density fields was investigated at extended-time drifting station 402. Figure 4a, b shows temperature and salinity distribution to a depth of 500 m during the period 28-29 January 1983. The character of vertical distribution is typical for winter: a homogeneous layer from 0 to 160 meters with a temperature of 15.1 degrees Celsius, followed by a weakly-marked thermocline upper boundary at the 170 meter level and its smooth drop to 14.1 degrees Celsius at a depth of 500 meters.

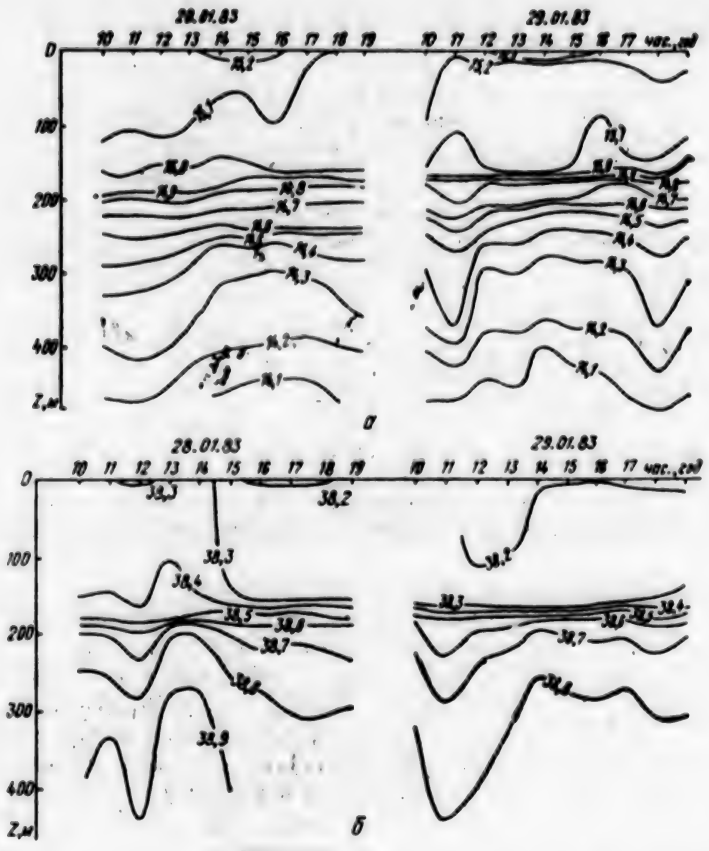

Figure 4. Space-time distribution of temperature (a) and salinity (b) in field area 2 (Station 402).

The microstructure of the upper 0-5 meter layer was investigated at Station 390, which revealed a subsurface microthermocline in a stage of disintegration over a period of approximately 1.5 years (Figure 5). The upper boundary of the microthermocline was situated in a layer at 1.85-2.0 m with maximum temperature and salinity gradients of 0.62 degrees/m and 0.25 °/00 per meter respectively. The temperature drop at 0.3 m was 1.05 degrees Celsius with an average gradient of 0.12 degrees/m. Elevated salinity at the surface (38.6 °/00) attested to intensive evaporation of the microlayer under the influence of the sun's rays. Below the microthermocline layer, beginning at 2.1 m, there was found a quasihomogeneous layer with temperature gradients averaging 0.02 degrees/m.

In winter the Adriatic region (Field Area 3) is absolutely homogeneous to a depth of 500 m. This area can serve as a good full-size model for studying the development of various hydrophysical processes during the forming of a seasonal thermocline, as well as for investigations with the creation of artificial hydrodynamic disturbances in the sea medium.

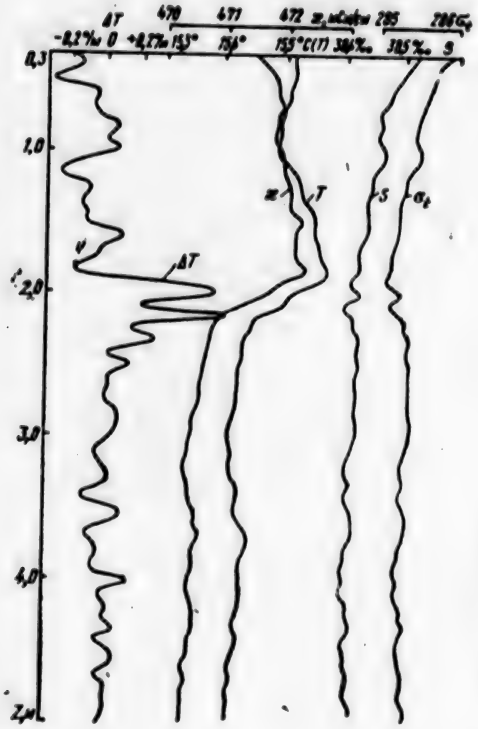

Figure 5. Microstructure of subsurface microthermocline in 0-5 m layer.

Resolution of practical problems connected with investigating the processes of transport and diffusion of a passive admixture in the ocean requires experiments with various types of "dyes"--tracers of the hydrophysical processes of dissipation of an admixture in full-scale conditions. Natural radioactive isotopes which are present in the waters of the oceans and seas should be considered to be the most promising tags in this regard, and in particular natural gamma emitters, which make it possible to conduct measurements directly "in situ." In connection with this, an important role is played by investigation of the background parameters of the gamma radiation field of the upper layer of seawater.

A nonradioactive (cosmic) component and a radioactive component are the principal constituents of the gamma radiation field. The radioactive component is caused by the presence of four principal emitters, the activity of which is 3 to 4 orders of magnitude greater than that of the others: natural K-40 and members of the radioactive series V238--RaC and RaB, bombardment C-137 and cosmogenic Be-7. It is important to note that the absolute contribution in the field by two to three orders of magnitude. The experts, however, are vigorously discussing the question of the correlation of parameters of variations of the above-named components for different areas of the World Ocean (Second All-Union Symposium on Combined Study of the Hydrophysical Fields of the Ocean Employing Isotope Methods, Vladivostok, 1981; Second All-Union Congress of Oceanographers, Yalta, 1982). A number of authors [2] believe that potassium-40 plays the principal and frequently exclusive role in forming variations of the gamma radiation field.

The author of [3] proposes a model of formation of seawater gamma radiation field. It boils down briefly as follows: in the upper 5-20 meter water layer field variations are caused by the nonradioactive and the bismuth component; for open-sea regions of the World Ocean variations in the potassium component are tighly linked with variations in seawater salinity. In connection with this, for depths greater than 30 meters and typical scales on the order of hundreds of meters to tens of miles (horizontal), meters to tens of meters (vertical), and minutes to days (time), the principal role is played by the Bi-214 component--daughter product of the decay of radon-222.

A specialized experiment was conducted for the purpose of estimating the degree of adequacy of the model in open-sea areas of the Ionian and Adriatic Seas. It essentially consisted in determining the variable component by means of synchronous measurements of fluctuations in radiation intensity and concentrations of individual components in the most representative areas and water masses and demonstrating an absence of variation of other components under given conditions. Formulation of the experiment called for estimating the parameters of variation of intensity of gamma radiation and concentration of potassium in the upper water layer over a substantial part of the Ionian and Adriatic seas, as well as at locations of the largest gradients of hydrologic characteristics; selection of field areas with minimal fluctuations of the stated characteristics; synchrononous investigations of the fluctuation parameters of gamma radiation fields, concentrations of Rn-222 and potassium.

Investigations by a spectrometry team at drifting stations (400-403) with the aid of a three-channel gamma-spectrometer [3] indicated that in the upper layer of seawater, with extremely low variations in hydrologic characteristics of water masses (salinity variations did not exceed 0.1 °/00), there are considerable (at 0.3 percent confidence level) fluctuations in intensity of radiation across a broad energy spectrum. They are recorded in energy ranges from 0.1-0.3 to 3.5-4.5 MeV.

The statistical characteristics of the parameters of these variations suggest that for depths at which the cosmic-ray component of the gamma radiation field is small, they are caused by changes in intensity of bismuth-214 radiation. This is confirmed, first of all, by the cascade nature of the varying component; secondly, by the considerable fluctuations in the transpotassium and hard radioactive bands, and finally, by a characteristic ration of magnitudes of fluctuations in the various energy bands, which correspond to the spectral composition of bismuth-214 radiation. The statistical parameters of fluctuations change considerably in the upper 20-30 meter water layer: variations in the nard energy band are considerable. Their ration across the full spectrum, obtained on the basis of analysis of a paired correlation coefficient matrix, has a characteristic appearance which corresponds to the spectral composition of the cosmic-ray component.

In our opinion these conclusions are statistically supported rather well. According to the results of analysis, fluctuations greatly exceeded confidence intervals for a 0.3 percent confidence level. As a rule the ratio of parameters of instability of the operation of individual spectrometer channels and magnitude of actual pulsations did not exceed 30 percent. Those regions of the paired correlation coefficients matrix which corresponded to the variable component were restricted by correlation coefficients not less than 0.7. The obtained results exclude potassium-40 as a possible variable emitter.

Fluctuations in the bismuth component in the vicinity of the lower boundary of the quasihomogeneous layer show a broad frequency spectrum with a typical scale from tens of minutes to 24 hours. One can isolate low-frequency (12 hours) and high-frequency (to 1 hour) components, which apparently is due to the existing wave field and hydrometeorological conditions in the field area. Special investigations must be conducted to obtain a precise identification of these processes.

A towed gamma package, which operated in a radiometer mode, was used to detect variations in the gamma radiation field on a large space-time scale.

On the whole an analysis of the statistical information obtained by radiometer in field areas 2 and 3 enables us to transfer the above-presented conclusions to the Ionian and Adriatic seas. Although the radiometer has a lower statistical certainty of measurements than the spectrometer which was utilized, the indicated fluctuations in intensity of radiation were clearly recorded throughout the entire investigated area for depths of greater than 30 meters. The statistical fluctuation parameters are the same as recorded at the drifting stations.

Parameters of Synchronous Fluctuations of Seawater Activity at Station 402

Параметри синхронних флуктуацій активності морської води на станції 402

(1) Компонента	(2) Приріст середнього	(3) σ_{n-1} за час осереднення	(4) Похибка приросту для 30 % рівня значимості
«Кушка» (5) (спектрометр)	—0,11 —0,16	0,59 0,61	0,02 0,02
«Сатурн» (6) (радіометр)	—0,9 +0,3	0,98 0,96	0,5 0,5
Rn^{222}	—0,44 —0,42	0,49 0,87	0,22 0,20
K	+0,002 +0,0003	0,16 0,17	0,8 0,3
Солоність (7) *S*	— +0,03	— 0,70	— 0,01

Key to table: 1--component; 2--increment of average; 3--for averaging time; 4--error of increment for 30 percent confidence level; 5--"Kushka" (spectrometer); 6--"Saturn" (radiometer); 7--salinity

The radiochemistry team investigated the parameters of distribution of aggregate potassium at all stations and along the vessel's route. The obtained data indicated uniformity of distribution of potassium (maximum deviations from the average amounted to 0.5 percent). Frequent taking of surface and depth samples (spatial scale 300 and 150 m) produced similar results.

While the vessel was proceeding along its course, samples for analysis would be taken every 2-3 hours (20-30 miles). Results indicated that rather considerable variations in potassium content are observed in different areas (open sea, shelf zone), variations which adequately follow changes in salinity. The K:Cl ration in the samples, however, is constant (0.0206-0.0207) and does not go beyond the boundaries of the confidence intervals of error of the ionometric method. Analysis of samples taken at hydrologic stations (in field areas 2 and 3) to maximum depth levels confirmed the existence of a strong interlinkage in distribution of potassium and salinity.

For geochemical processes with a typical time scale of more than 20 minutes, bismuth-214 (daughter product of decay of radon-222) remains in a state of equilibrium: its distribution curve follows that of radon. The process of gas exchange between atmosphere and ocean, whereby thickness of the laminar film on the water surface is a limiting factor, constitutes the basis of a model of the radon component of the radioactivity field of seawater. The results of investigations of the space-time structure of the radon concentration field performed by the radiometry team suggest that in spite of a high degree of homogeneity of hydrologic conditions in the field areas in the Adriatic and Ionian seas, considerable variations (5 percent confidence level) of radon concentration, which amount to 50-70 percent of average value, are observed to depths of 170 meters. Variability of hydrometeorological conditions in the field areas defines the parameters of gas exchange across the water-air interface. Average values of laminar layer thickness proved to be 81 ± 8 microns. The hydrometeorological conditions variability regime in the field area in the Adriatic has a short-period component with a characteristic time scale on the order of 12 hours. This component causes restructuring of the vertical profile of radon-222 concentration in the upper 30-40 meter water layer; reversal of the radon-222 flux direction was observed during a sensing period in the order of 24 hours in the field area in the Adriatic.

The field of distribution of concentrations of radon-222 in deep water layers also shows considerable variations, the magnitude of which is determined by the long-period component of variability of hydrometeorological conditions. The characteristic time scale of these fluctuations, recorded in the vicinity of the lower boundary of the quasihomogeneous layer, ranges from several to 12-20 hours. In order to identify the variable emitter, scientists took synchronous mreasurements of the parameters of gamma-field fluctuations and concentration of radon and total potassium on the lower boundary of the quasihomogeneous layer (95 m) in field areas 2 and 3 at drifting stations 400 and 402, running from 3 to 5 days. These sensing conditions entirely eliminated the influence of the cosmic-ray component and provided for the presence of maximum gradients of hydrophysical characteristics. Synchronous sensing was ensured by placing the instrument sensors and sampler on a single rigid frame.

We shall note that these parameters were measured with a differing degree of accuracy: from 1 percent for the bismuth component of gamma radiation with

spectrometer measurements, 5 percent for the radiometer, and from 1 percent for total potassium to 30 percent for radon-222. Therefore in order to compare the obtained results the requisite averaging operations were performed, which made it possible to reduce radon error, let us say, to 8-10 percent. Long-period fluctuations in radon activity proved to be considerable.

Some of the results of synchronous measurements of seawater activity fluctuations at Station 402 are given in the table. Time intervals with significant variations were noted in the radon concentration measurements (deviations from the average value exceeded to root-mean-square deviations). Such fluctuations were observed on 27 January 1983 from 0245 to 1745 hours (upper line in the table) and on 28 January 1983 from 0445 to 1745 hours (lower line). During this time, according to the data of the "Kushka" probe, there was noted a decrease in radiation intensity by 5-8 γ. The "Saturn" probe also recorded similar fluctuations in activity, which exceeded the confidence intervals. Significant variations in concentration of total potassium were not determined (deviations were much less than method error), while changes in salinity were of the opposite sign.

Thus on this voyage scientists obtained reliable confirmation of the adequacy of the seawater gamma-background model. Full-scale investigations of nuclear-physical and hydrochemical parameters, as well as investigations of the characteristics of variations of individual components of the radioactivity field showed the importance of the bismuth component. No substantial variations of the potassium component of the gamma radiation field were discovered.

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'RAZREZY' PROGRAM RESEARCH IN THE TROPICAL ATLANTIC

Kiev VISNYK AKADEMIYI NAUK UKRAYINS'KOYI RSR in Ukrainian No 4, Apr 84 pp 13-19

[Article published under the heading "Scientific Surveys and Brief Articles," by UkSSR Academy of Sciences Academician B.O. Nelepo and Doctor of Physical-Mathematical Sciences V.V. Yefimov]

[Text] It has been established that the World Ocean is a climate-forming factor and plays an important role in the forming of long-period weather anomalies or short-period climate fluctuations. Therefore further advance in numerical methods of weather forecasting is impossible without correctly taking into account the ocean's influence on atmospheric processes. This assumption is based on several factors: the heat energy of the ocean is much greater than that of the atmosphere; greater magnitudes of typical development time and existence of synoptic disturbances in the ocean; substantial south-north heat flows, which are transported by ocean currents from the equator to the poles, etc.

It is not possible in the immediate future to obtain adequate information from the entire expanse of the World Ocean. There exist regions in the World Ocean, however, characterized by much greater activeness of the processes of energy exchange with the atmosphere and maximum heat advection. Such regions should be of primary interest for solving the problems indicated above. The concept of energy-active ocean zones proposed by Academician H.I. Marchuk forms the basis of the "Razrezy" ["Sections"] program [1, 2].

One of the principal component parts of this program (full name--"Program of Investigation of Interaction Between Atmosphere and Ocean for the Purpose of Studying Short-Period Climate Changes") is investigation of the processes of accumulation and transport of heat in the energy-active tropical region of the Atlantic Ocean.

The theoretical and experimental aspects of the overall program are presented in [3]. Investigations in the energy-active tropical zone are integrated within the framework of the "Teplozapas" [Heat Budget] subprogram, the principal task of which consists in elucidating the physical mechanisms of formation of the average south-north heat flow across the equator in the Atlantic Ocean and its possible anomalies. It has been shown in recent studies by Timofeyev [4] and Hastenrath [5] that the equatorial region of the Atlantic Ocean differs substantially from analogous regions in the Pacific and Indian oceans. A total average annual quantity of heat is transported across it from south to north which equals (100-130) x 1013 w. As we see, this is a substantial quantity, and therefore anomalies in this transport can significantly affect weather formation in Europe, especially in the European part of our country.

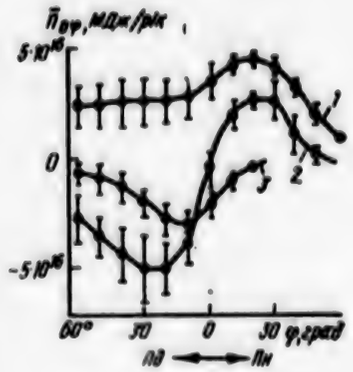

Figure 1. South-north heat flows in the Atlantic (1), Pacific (2) and Indian (3) Oceans according to the estimates in [4].

Figure 1 shows estimates of south-north heat transport in various latitude zones in the Atlantic, Indian, and Pacific Oceans, which show that the greatest heat advection between latitudes is indeed characteristic of the Atlantic. Of greatest interest in the course of experiments on the "Heat Budget" project is a direct estimate of the heat which is transported from south to north by the system of currents in the ocean's western boundary region, in the area of currents of western intensification. At the same time scientists are studying seasonal variability of the temperature field of the tropical region of the ocean and a number of other items (wave oscillations across a broad range of frequencies, etc.).

Studies of the equatorial regions of the oceans are being actively pursued in many countries. In the Atlantic Ocean, for example, since 1982 work has been in progress on the French Focal and the U.S. Sequal programs to study seasonal variability of oceanic processes in the tropical region. One specific feature of the "Heat Budget" project is primary attention focused on the formation and variability of hydrophysical fields in the western part of the equatorial region--the area of most probable localization of south-north heat transfer.

Field investigations are conducted according to the standard run method, mandatory elements of which are the mesoscale Amazon ocean field area, extended by a hydrophysical section, and two south-north transequatorial sections (see diagram of tropical field area in Figure 2). Hydrophysical sections No 1 (23 degrees W.L.) and No 2 (30 degrees W.L.) include measurement of vertical temperature and salinity distributions by automated probes at stations located 60 miles from one another. Additional measurements on the sections call for sensing by towed equipment during vessel travel.

The Caribbean Hydrophysical Sections are designated for studying the hydrologic structure of the northwestern part of the tropical region of the Atlantic Ocean and the variability of this structure. Several sections are being made (one or two on each research vessel voyage), aimed at detailing the structure of hydrologic fields of the processes of transport in the Caribbean and Antilles region.

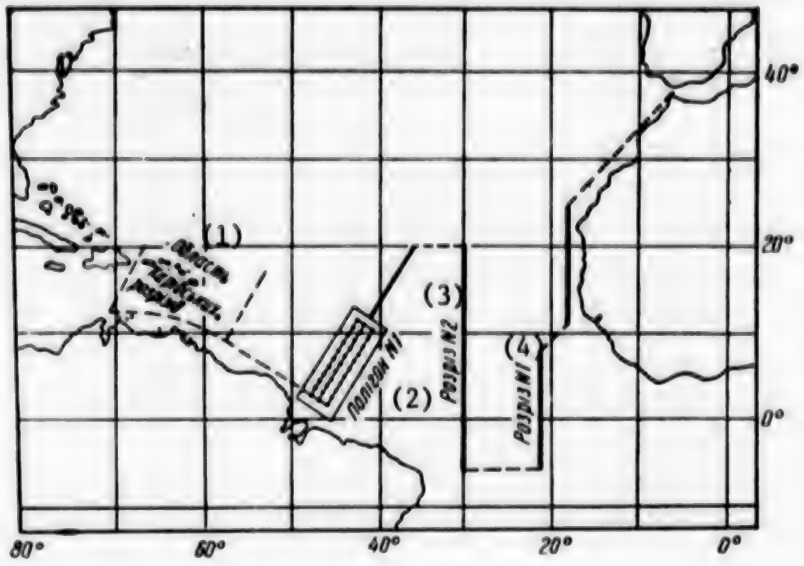

Figure 2. Diagram of patterns in tropical field test area.

Key: 1--Caribbean sections region; 2--Field Area No 1; 3--Section No 2; 4--Section No 1.

Mesoscale Ocean Area 1 contains a grid of three sections. The coordinates of the central section are as follows (approximately): 20 degrees north latitude-3 degrees north latitude-36 degrees west longitude-46 degrees west longitude. The shortened lateral sections are ± 60 miles from the central section. A denser network of stations (spaced at approximately 30 miles) is planned for the northwestern part, in the region of major currents of the Antilles-Guiana system.

Measurements at hydrologic stations in the mesoscale ocean area are to run to a depth of 2,000 meters, plus the placement of 3-4 long-running autonomous buoy stations (ABS) with self-contained instrumentation for measuring temperature and current velocity in the northwestern and central parts of the field area.

Readings in the field area are taken once each season (four times a year). The first measurements were taken in 1981. The research vessel "Akademik Vernadskiy" has made four voyages to date, the most recent of which was in January-April 1983. A total of 9 sensing runs totaling 10-25 days were made in the test area, during which scientists measured current velocities and temperatures at various depths, salinity, meteorological parameters, and other characteristics. We should note that in the course of the investigations considerable work was done to improve methods and equipment to be used for extended sensing of principal hydrophysical parameters in the region of the Amazon Field Area. During the last two voyages of the research vessel "Akademik Vernadskiy" scientists measured currents during a period of almost 2 months. In particular, on the last voyage they succeeded in obtaining synchronous data on currents at several points of the Amazon Field Area with the aid of submerged autonomous buoy stations (PABS). Current and temperature records characterize average values and mesoscale variability of velocity and temperature fields in the area of a synoptic time scale.

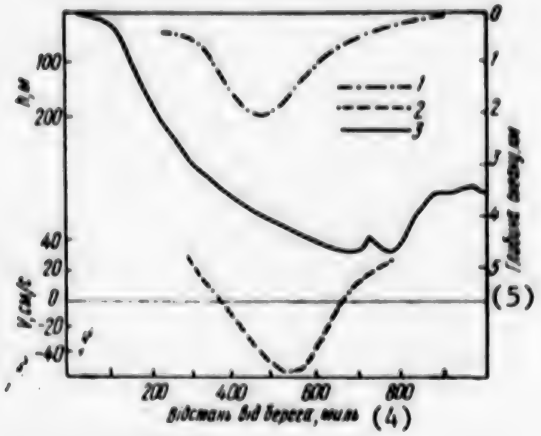

Figure 3. Change in depth of upper quasihomogeneous layer h (1) and normal velocity component, averaged in layer 0-100 m (2), on a section in the Amazon Field Area; 3--ocean bed profile.

Key: 4--distance from shore, miles; 5--ocean depth, km

Figure 3 shows standard temperature field behavior on a section through the Amazon Field Area and the current velocity component normal to it. The diagram shows depth of the lower boundary of the upper quasihomogeneous layer h and normal current velocity averaged in layer from 0 to 100 m. As we see, one notes substantial changes in quantity h (in the range from 20 to 180 m), in relation to distance to the coast of South America. We note that in the Amazon Field Area the isolines of depths on the continental shelf are close to parallel, while the section proper is oriented at a right angle to these isolines, which simplifies interpretation of the results of field investigations.

The system of currents has a typical appearance, fully in conformity with changes in temperature and salinity (and hence density as well) vertically and perpendicular to the coast. They conform rather well to the geostrophic correlation, according to which the normal component of velocity

$$v(z) = \int_{z_0}^{z} \frac{1}{f\rho} \frac{\partial p}{\partial x} dz + \text{const},$$

where ρ --density, p--pressure, z--depth, $f=2\Omega\sin\varphi$--Coriolis parameter, φ--geographic latitude, x--coordinate directed along the section. An exception is the southernmost part of the section, located in immediate proximity to the equator, where geostrophic correlations may be disturbed. On the whole the system of currents has the following appearance: the northwesterly-trending Guiana Current along the coast (to latitude $\approx$ 4 degrees), a countercurrent flowing in the opposite direction, which is also a major current (in the area $\approx$4-7 degrees) and, finally, the North Equatorial Current (in an area of latitudes greater than 10-12 degrees). The maximum velocities of the Guiana Current and countercurrent (which is usually called the Equatorial Current) are relatively large (to 80-100 cm/s); the North Equatorial Current has the greatest velocities, but the latitude region it occupies is greater than that of the

preceding currents. Each of the above-named currents carries a large quantity of mass and heat--(20-30) x $106m^3/s$, which is commensurate with the quantities requisite to explain the observed south-north transfers across the equator in the Atlantic. This confirms the correctness of selection of the test area as one of the ocean's energy-active regions.

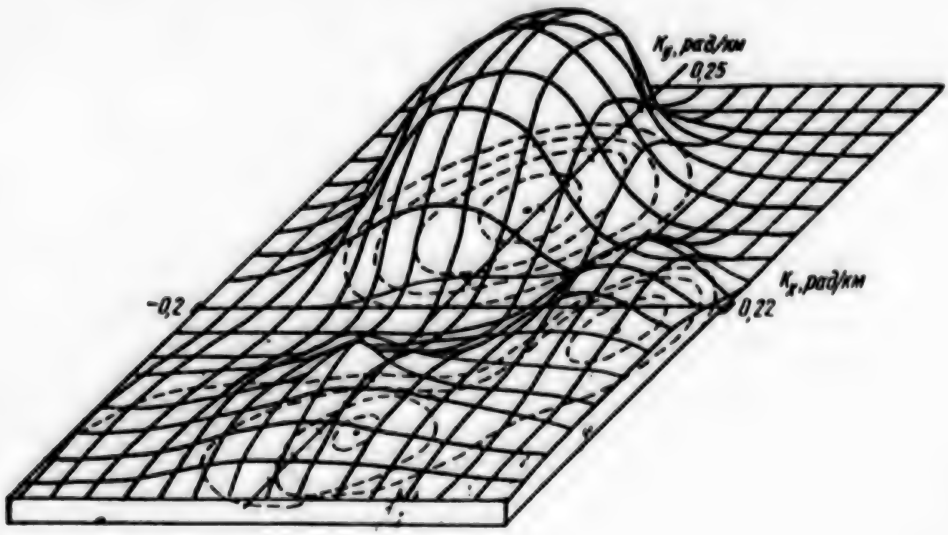

Figure 4. Space-time spectrum of semidiurnal internal tide fluctuations close to the equator.

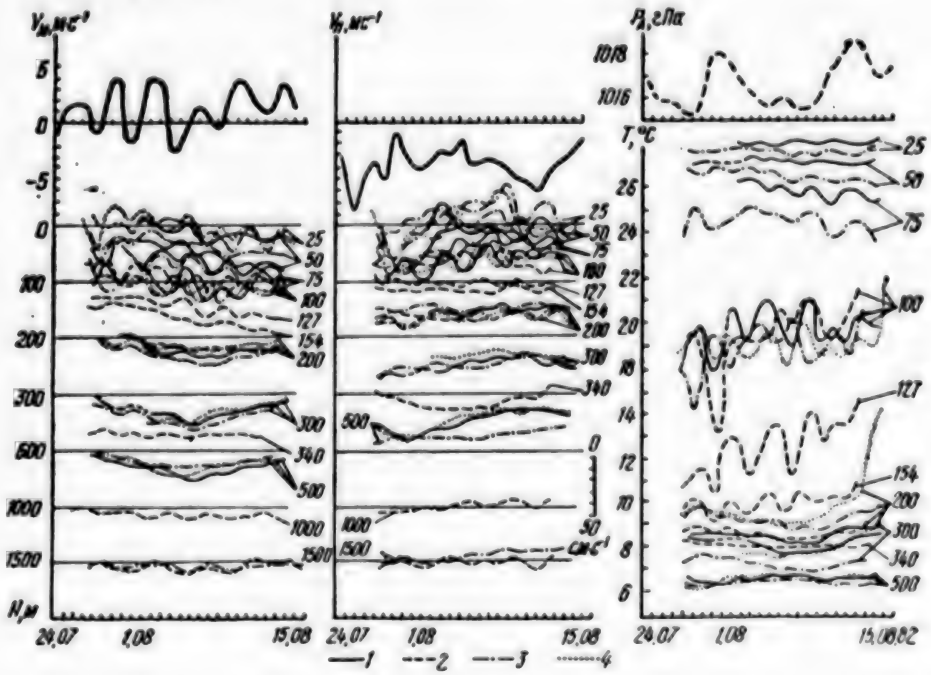

Figure 5. Change with time of the north-south V_m and zonal V_n components of current velocity and temperature T at various depths, measured by autonomous buoy stations (ABS). The upper part of the diagram shows the north-south and zonal components of wind velocity and atmospheric pressure P. The figures 1-4 indicate data obtained from different ABS.

One encounters a number of difficulties, however, in obtaining correct estimates of heat advection of the above-specified system of currents, as well ad determination of possible anomalies. Experimental material obtained to date is insufficient to provide an unequivocal answer to the questions posed; additional field investigations are needed. The greatest complexity consists in the considerable space-time variability of currents around the Amazon Field Area and the section. South-north transfers can be estimated reliably only following detailed study of the spectrum of fluctuations.

The physical nature and types of current velocity fluctuations around the Amazon Field Area are very heterogeneous. We shall examine the variability of hydrophysical fields successively for different time scales.

First of all, we must take into account short-period oscillations--internal waves with periods of up to 1 day. Intensive oscillations occur in the area of the two major currents, with a period of approximately 1 hour, which constitute waves close to average internal waves [6]. The mechanism of their generation has not yet been precisely established. As was to be expected, in addition to those mentioned above there are internal waves of a tidal period with the predominance of a semidiurnal wave (≈ 12 hours). The latter were specially studied previously, although in a water mass somewhat displaced relative to the field area [7]. The continental shelf zone of the ocean is the probable site of generation of such oscillations. The direction of propagation of these waves runs from the coast in a northeasterly direction. Figure 4 contains a space-time spectrum at a frequency corresponding to the internal waves of the tidal period [7]. As we see, we expect a clear-cut energy maximum for spectral components with a wave vector of a northwesterly direction.

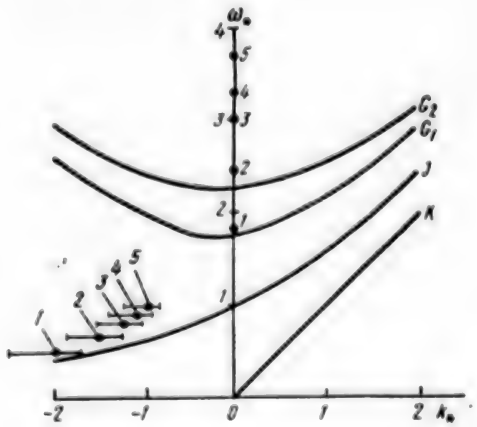

Figure 6. Dispersion diagram of equatorial waves. $G_{1,2}$--first and second modes of inertial-gravitational waves; J--mixed, K--Kelvin, in the lower left-hand part--different types of Rossby waves. Points 1-5--experimental estimates.

Secondly, intensive oscillations with a period of 3-4 days are always present in the test area in the upper active ocean layer. They are concentrated in an upper layer of 100-150 m (trapped by the surface) and are almost totally absent at lower depths. Their nature is obviously connected with inertial oscillations caused by wave stress pulsations on the surface. Figure 5 contains figures for velocity components obtained at one of the buoy stations. The mentioned oscillations which encompass the upper ocean layer are clearly evident.

A third class of wave oscillations, which has a broad range of periods (from several days to several tens of days), are the equatorial entrained waves. They are generated and propagated in a wave channel which is localized near the equator. Since the southern part of the Amazon Field Area is situated close to the equator, certain types of equator-entrained waves may be important here. The field area is located in the western part of the ocean, and therefore waves propagating westward (or more precisely those whose energy-flow velocity is directed westward) are the most developed.

A theoretical dispersion diagram (Figure 6) links frequencies ω^* and zonal wave numbers k^* of equatorial waves. Inertial-gravitational, Kelvin, mixed, and Rossby waves are present in it. Negative values of k correspond to westerly, and positive values to easterly directions of wave propagation. In this same diagram the dots indicate experimental wave parameter estimates which were expected close to the equator during the 20th voyage of the research vessel "Akademik Vernadskiy" [8]. The confidence intervals of the experimental estimates are indicated by horizontal segments. Thus close to the equator waves propagate in fact from east to west which can be considered of the mixed type--with a period of approximately 20 days and a length of 1,000 km.

Apparently mixed waves will reach the western edge of the ocean and reflect back from it. As a result reflected Kelvin waves and continental-shelf entrained waves will form. Therefore in the vicinity of the field area the contribution of both direct and reflected waves should be considerable. There exist several mechanisms of generation of equatorial waves. The most important among them are instability of the system of zonal equatorial currents and the direct effect of propagated atmospheric disturbances.

One can consider as a fourth class of wave oscillations those which occur as a consequence of multiple-stream currents in the area of the Guina Basin. Here are formed, first of all, persistent boundary modes, which propagate along the currents, the amplitude of which attenuates as they move away from the current boundaries [9]. Secondly, general indications are that the system of differing-direction currents should be unstable, as a consequence of which fluctuating disturbances increase with time. Their detailed hydrophysical investigation presents significant mathematical difficulties, due to the complex nature of the density and velocity fields in the Amazon section (see Figure 3). The results of numerical calculations depend to a significant degree on the initial $\rho(x, z)$ and $v(x, z)$ fields. Therefore determination of averaged fields requires additional extensive detailed measurements of the principal hydrophysical parameters in the section.

Finally, just as in any region with intensive average currents, large-scale synoptic disturbances have been discovered in the western tropical region of the Atlantic, disturbances which are connected with vortex formations. Such

formations ("rings") are known to exist in regions adjacent to the Gulf Stream, Kuroshio, and other currents. Recently similar disturbances were discovered during the 26th voyage of the "Akademik Vernadskiy" in the Amazon Field Area. They are traced on the basis of a number of indications, which include a T, S structure of waters (presence of fresh water of Amazon origin) and the optical properties of water masses. The latter is manifested in a sharp decrease in transparency of surface waters, which evidently is directly linked with the transport of masses of Amazon waters from coastal areas. This feature is extremely informative and enables one to trace the propagation of "patches" of waters of elevated turbidity with optical methods (or by rapid measurement methods from shipboard as the vessel proceeds, or by remote noncontact methods--with the aid of satellite sensing.

Figure 7 shows the distribution of the discovered contrasting waters of Amazon origin; it is well explained by the mechanism of transport of Amazon waters into the ocean as a consequence of development of a Guiana Current meander (ring). The physical mechanism of development of the described intensive disturbance is apparently connected with the baroclinic stability of this current.

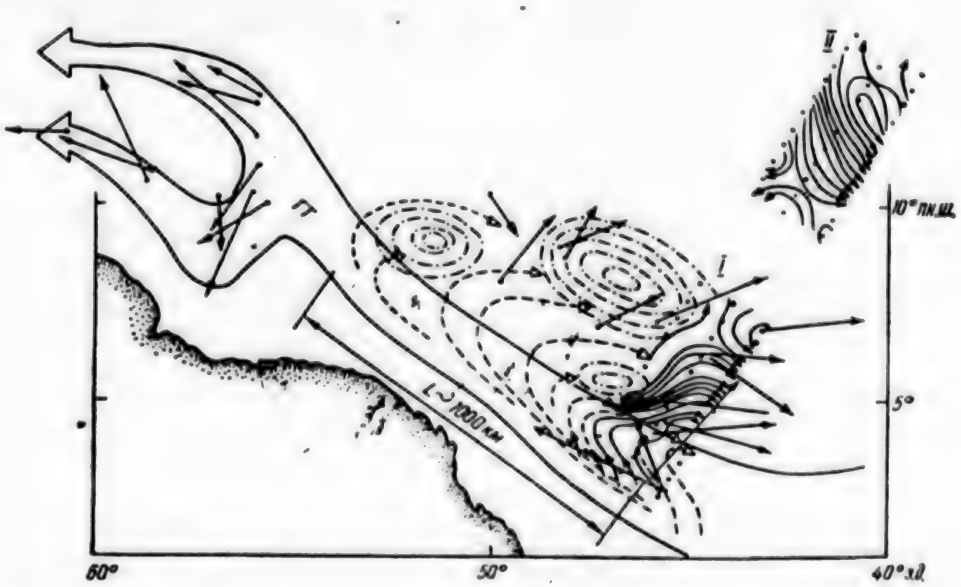

Figure 7. Diagram of surface currents (indicated by arrows) and a region of diminished transparency of surface waters (---) in the northwestern part of the tropical equatorial region.

Concluding our brief analysis of the types and physical mechanisms of oscillations of hydrophysical fields in the energy-active western region of the Atlantic Ocean, we shall note that their existence is reflected in estimates of advective flows and heat content in the upper active ocean layer. Instantaneous values may differ substantially from averaged ones (the difference

sometimes exceeds 100 percent). The above-discussed effect is a direct indicator of the energy-activeness of the ocean area selected for investigation. Taking it into account for the purpose of obtaining adequate estimates of averaged south-north heat flows across the equator demands further systematic field investigations and utilization of new sensing methods. Among such methods we should mention the extensive employment of submerged buoy stations operating for extended periods (more than a year) and remote methods of monitoring the state of the ocean.

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NON-EXPLOSION SOURCES OF SEISMIC WAVES FOR MINE PROSPECTING

Minsk SOVETSKAYA BELORUSSIYA in Russian 9 Oct 84 p 2

[Text] Up until recently, explosions were used for the excitation of seismic waves for seismic studies in prospecting in mines of the Starobin Potassium Salts Deposit. Explosions are no longer practiced. Personnel of the Belorussian affiliate of the All-Union Halurgy Scientific Research Institute have developed several types of non-explosion excitation sources.

The introduction of this innovation at the Belorussian Potassium Production Association has made it possible to save 42,000 rubles in one year and to conduct seismic studies that are completely safe.

This innovation from Belorussia is recommended for introduction in the mining and chemical industries and other branches of industry.

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'KHIBINY' EXPERIMENT DESCRIBED

Moscow ZEMLYA I VSELENNAYA in Russian No 5, Sep-Oct 84 pp 12-19

[Article by Ye. P. Velikhov, academician, A. A. Zhamaletdinov, candidate of geological and mineralogical sciences, and M. S. Zhdanov, doctor of physical and mathematical sciences]

[Text] On the Kola Peninsula a powerful pulsed magnetohydrodynamic (MHD) generator is being used in "probing" for up to tens of kilometers into the depths of an enormous territory. This experiment is a sort of experimental test area where tests of new equipment and the new technology of deep electromagnetic soundings are being carried out.

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Electromagnetic Soundings of Earth

In the arsenal of geophysical methods for studying the earth's deep layers, in addition to seismic and gravimetric methods, an important place is occupied by electromagnetic methods. The essence of these methods is that the primary (external) electromagnetic field induces electrical currents in the earth's conducting layers which generate a secondary (internal) field. Special sensors at the surface register the total effect of these two fields. The electrical currents induced in the earth, and accordingly, the secondary field, are dependent on the distribution of conductivity in the earth. Thus, on the basis of electromagnetic measurements at the earth's surface it is possible to determine conductivity in the earth's deep layers and it can give information on the thermodynamic and phase states of rocks at great depths. This circumstance also predetermined the enormous practical importance of deep electromagnetic studies.

Deep electromagnetic soundings of the earth's crust and upper mantle have been carried out in our country and abroad since the 1950's. But until recently use was made primarily of natural field sources in such work. These are variations of the earth's magnetic field arising as a result of interaction between solar corpuscular radiation (the solar wind) and the magnetosphere and ionosphere at altitudes 100-200 km. Geomagnetic variations excite secondary fields in the earth which penetrate to a depth of tens and hundreds of kilometers and carry back information on structure of the earth's deep layers. These methods have been given the name magnetotelluric methods for geophysical research. The principal difficulty in processing and interpreting magnetotelluric data is that

the position and configuration of the magnetospheric and ionospheric field sources are unknown. In addition, as time passes there is a continuous change in their geometry and this introduces additional uncertainty in the interpretation of the results. In this connection, during recent years interest has increased in methods for deep electromagnetic soundings with artificial sources because in this case it is possible to take the geometry of the primary field into account and obtain more reliable information concerning the deep section. But on the other hand, it is necessary to have powerful transportable current sources. Truck and diesel sources with a power up to 60-100 KW are used for this purpose, but they make it possible to probe the earth to a depth of only a few kilometers.

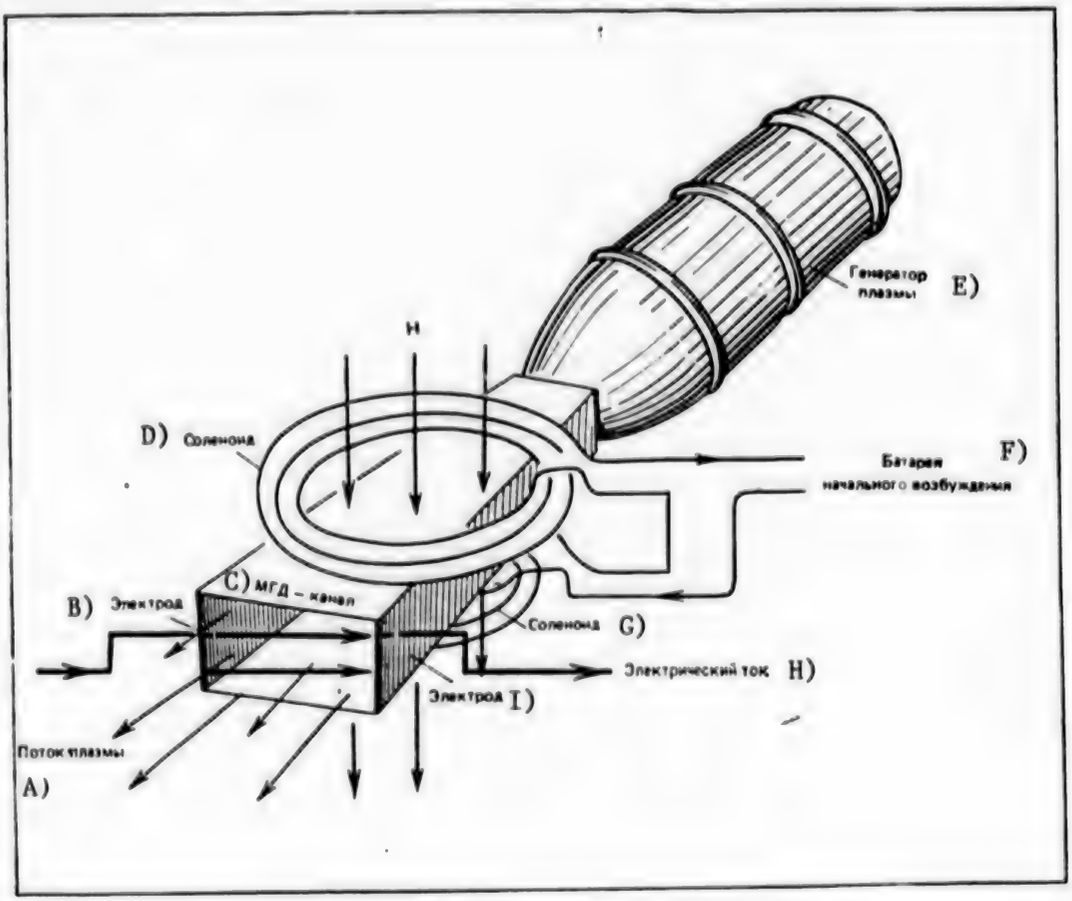
A new sharp rise was noted when powerful pulsed magnetohydrodynamic (MHD) generators began to be introduced into geoelectrics on the initiative of the Atomic Energy Institute imeni I. V. Kurchatov. These generators develop an enormous power -- up to 80,000-100,000 KW -- in short pulses. It is clear that the introduction of new technology in geophysics, as in other fields of science and production, involves great difficulties. It was necessary to develop both a new measurement base and different procedures for theoretical analysis and interpretation of the results. Accordingly, a series of experiments was first carried out in order to use MHD generators in solving some very specific problems in geoelectrics. One of these experiments was the "Khibiny" experiment, carried out on the Kola Peninsula with the participation of the Geological Institute, Kola Affiliate, USSR Academy of Sciences, the Atomic Energy Institute and the Terrestrial Magnetism, Ionosphere and Radio Wave Propagation Institute, USSR Academy of Sciences (IZMIRAN) and a number of other organizations.

The Kola Peninsula was selected as a research area because it is part of the territory of the Baltic shield, where the earth's most ancient formations emerge at the surface. Here it was found possible to make the most complete study of the structure of the crystalline basement, which usually almost everywhere is hidden beneath sedimentary rocks. It was also interesting to compare data from MHD sounding and the results from a superdeep hole being drilled on the Kola Peninsula.

"Khibiny" Source

The "Khibiny" MHD apparatus, operating on the Kola Peninsula, consists of two paired MHD generators. Each of these is a solid-fuel rocket engine transforming the energy of plasma into an electrical current. A solid fuel with admixtures of easily ionizing substances is combusted in the plasma generator. The conducting flow of "cold" plasma with a temperature of about 3,000°C arising in this case rapidly passes from the plasma generator into a MHD channel of rectangular section. The upper and lower walls of the MHD channel were made of a heat-resistant insulation material; the side walls, on the other hand, have metallic coverings playing the role of current collectors. Attached to the top and bottom of the MHD channel there are solenoids through which a high-intensity current passes from the initial excitation battery simultaneously with activation of the plasma generator. The current generates a transverse magnetic field in which the plasma flow is sharply slowed down. As a

result an electromotive force perpendicular to the magnetic field and the flow of conducting plasma arises between the electrodes in the plasma -- a moving conductor. After a full electric current is established, one of the MHD generators passes into a self-excitation regime and feeds an electric current into the windings of its solenoids and the solenoids of the second generator, whose energy is completely expended on supplying the radiating loop.



Schematic diagram of operation of MHD generator.

KEY:

A) Plasma flow
B) Electrode
C) MHD channel
D) Solenoid
E) Plasma generator
F) Initial excitation battery
G) Solenoid
H) Electric current
I) Electrode

The feasibility of using magnetohydrodynamic generators for sounding of the earth's crust is attributable to the fact that three time scales coincide: first, the time of penetration of the magnetic field into the earth's crust to a depth of tens of kilometers (seconds); second, lifetime of the magnetic field in a copper or aluminum coil of a definite weight (tons); third, time of penetration of heat into construction parts (seconds). The coincidence of these times makes it possible to construct compact and very powerful systems.

A distinguishing feature of the "Khibiny" radiating loop is that the natural conductor is the sea coast zone around Rybachiy and Sredniy Peninsulas. An aluminum cable weighing 160 tons was laid on the isthmus between Sredniy Peninsula and the continental part of the Kola Peninsula. The current of the MHD generator flows along the cable into the gulfs and diffuses in the sea, forming singular divergent current loops with a radius of 50-100 km (approximately 15% of the current leaks through rocks on the sea floor into the earth's crust).

According to experimental estimates, the magnetic moment of the source was about 10^{14} A·m^2; this is a million times more than in ordinary deep sounding apparatus based on the use of truck generators. Sources of such power were not known earlier in the practice of deep geoelectrics.

The following entirely legitimate question arises: is not marine ecology disrupted when such sources are in operation? Specially made computations have shown that the current density in the sea during the experiment, due to the great depths involved, is insignificant -- $2 \cdot 10^{-2}$ A/m^2; however, the potential drop per meter does not exceed a hundredth of a volt. If, in addition, an allowance is made for the brevity of operation of the generator (10-15 sec), this is entirely safe for the underwater world. The calculations were confirmed in investigations of the sea floor which were made immediately after triggerings of the MHD generator near the site of the experiment.

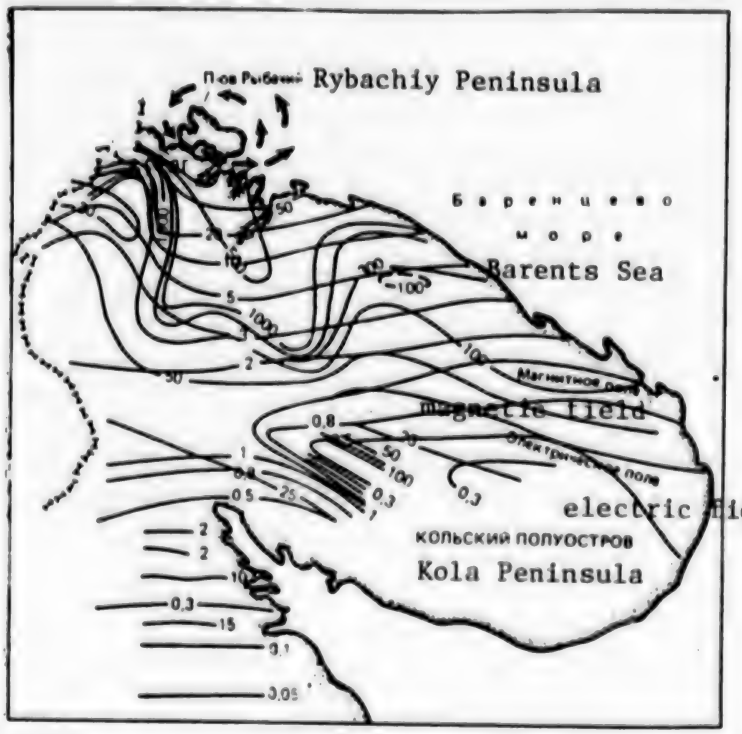
The powerful magnetic field of this "Khibiny" source extends high upward, at an altitude of about 100 km in the ionosphere creating disturbances with an intensity up to 10 gammas. This can give rise to geophysical effects important for interpreting the results of deep sounding of the earth and for study of ionospheric parameters.

Thus, the "Khibiny" experiment makes it possible to solve not one, but several problems related to the physics of the earth and the ionosphere and the shelf zone of the sea.

Geophysical Results

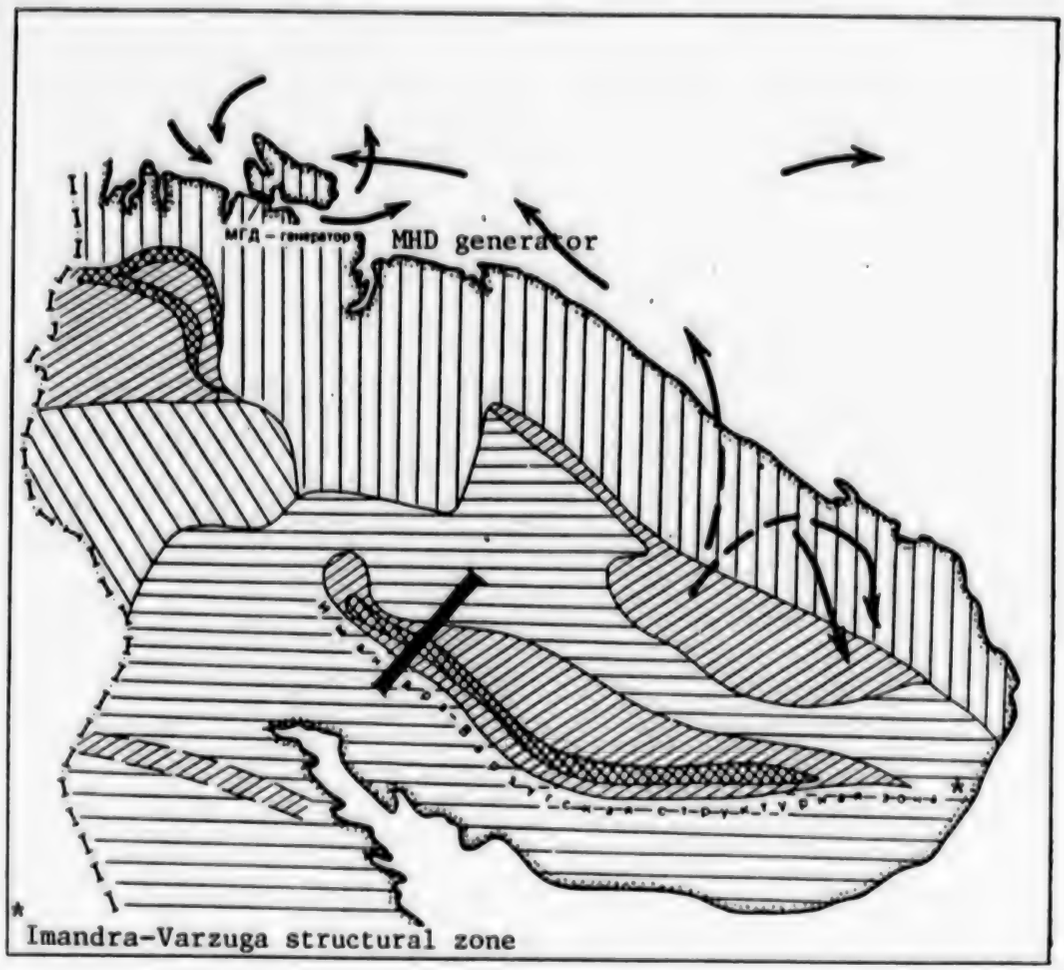
Experimental observations of the electromagnetic field generated by the "Khibiny" source were made over the entire area of the Kola Peninsula, in Northern Karelia, and in recent years also in the territory of Finland (the maximum distance from the source was 750 km). The principal measurements were made with spacings as great as 400-500 km with use of five-component digital and analog stations registering the electrical and magnetic field components. In these measurements, in addition to the Geological Institute, Kola Affiliate, USSR

Academy of Sciences, Atomic Energy Institute and IZMIRAN, other organizations are also participating, such as the Ukhta Geophysical Trust, the Geophysics Institute, Ukrainian Academy of Sciences, Geophysics Institute, Ural Scientific Center, USSR Academy of Sciences, Oceanology Institute, USSR Academy of Sciences and Kiev State University. In the implementation of the "Khibiny" program an important role has been played by Academician B. P. Zhukov, G. I. Gorbunov, corresponding member, USSR Academy of Sciences, Yu. M. Volkov, doctor of physical and mathematical sciences, and A. V. Pisakin, doctor of technical sciences.



Isoline map of vertical component of magnetic field in gammas (black lines) and modulus of electric field in mV/km (colored lines). The map was prepared on the basis of the results of measurements of signals of MHD generator on Kola Peninsula and in Northern Karelia. The arrows at top indicate the direction of spreading of electric currents of MHD generator in sea.

The enormous scales of the experiment made possible a new formulation of the problem of study of deep conductivity of the earth's crust. In the first stage a study was made of the structure of conductivity in the upper, approximately 10-km thickness of the basement over a great area. Earlier it was assumed that a crystalline shield is a relatively homogeneous region consisting of poorly conducting rocks. However, data from MHD sounding gave a different picture: the investigated region consists of about ten large blocks with different resistivity (from 10^5 to 10^2 ohm/m). Their areas at times attain tens of thousands of square kilometers. The most conductive blocks are related to territories promising for different types of ores which are of interest for exploration work (for example, the Pechenga, Imandra-Varzuga blocks). The isolines of the magnetic and electric fields bend sharply and crowd together near them.



Block structure of upper 10-km layer of earth's crust on Kola Peninsula obtained by means of MHD soundings. The different blocks (shown by different patterns) have different longitudinal conductivity. The colored arrows show the current-conducting channels within the limits of blocks within which ores may be found. The thick short line is one of the profiles of the field of a MHD generator cutting the Imandra-Varzuga structure.

In the course of the research it was possible to detect an important feature -- the presence of current-conducting channels within the limits of blocks which may contain ores. Horizontal currents are formed in the channels, evidence of a through layer-by-layer electric coupling between elementary conductors, sometimes for a distance of more than 100 km.

A detailed study of the geometry of these currents, together with areal mapping of the electromagnetic field, affords prospects for study of the deep structure of ore fields with a MHD generator. In precisely this way it was possible to detect the peculiarities of bedding and electrical coupling of rocks in the Pechenga structure and the Imandra-Varzuga structure. In addition to these structures, which may well contain copper-nickel mineralization, it was possible

to detect and study several anomalies in regions which may well contain titanium-magnetite and rare earth metals. In the territory of Finland it was possible to detect an earlier unknown conducting zone with an extent of 100 km, detected precisely in this experiment. Still another important result was a petroelectric map of conductivity of the upper (10-km) layer of the earth's crust in the territory of the Kola Peninsula, compiled on the basis of data from MHD sounding. It undoubtedly will play its role in future geophysical exploration work.

The "Khibiny" MHD source gave its first results in a study of the layer of sediments on the shelf of the Barents Sea. In the neighborhood of one of the structures there was a marked increase in longitudinal conductivity, indicative of an increase in the thickness of the sediments.

All these studies, although having practical significance, constituted only a preliminary stage in study of the conductivity of great -- up to 100 km -- depths. This problem already has fundamental importance and is necessary in a study of the physics of the earth's deep layers, investigation of the thickness of the earth's solid mantle (lithosphere), the depths at which the top of the heated and therefore well-conducting rocks of the upper mantle are situated. However, the block structure of conductivity of the upper part of the basement, detected in the first stage of the investigations, makes solution of this problem difficult. The fact is that the echo of the electromagnetic signals reflected from the deep horizons is refracted at the boundaries of near-surface blocks and is difficult to interpret. Everything is also complicated by the fact that the current pulses have a nonrectangular shape and the parameters of the sea current circuit change as the current drifts from the shoreline into the sea. Nevertheless, on the basis of experimental data it could be shown that the conducting blocks here can have the nature of covering structures with a thickness not greater than 15-20 km. They lie on the surface of a very ancient basement formed in the earliest stage in the earth's development. Extensive shows of this very ancient basement were discovered already in the first stage of investigations in the territory of the Murmansk block, in the Kovdor region, in Northern Karelia and in Finland. Such zones of highly conductive rocks evidently serve as singular windows for the electromagnetic field through which it is possible to "inspect" the deep layers to great depths. Work on deep electromagnetic sounding with a MHD generator was concentrated specifically in these zones.

The frequency electromagnetic sounding method (in the frequency range 1000-0.05 Hz) was used in studying the upper part of the earth's crust. The resulting geoelectric section can be regarded as a "standard" section of the crystalline basement, characteristic for the shields and ancient platforms. A special feature is a high resistivity and a great thickness of the intermediate poorly conducting layer. The subcrustal conducting layer in the upper mantle, caused by the effect of high temperature, was discovered at a depth of 100-150 km.

A geological interpretation of the data shows that the lithosphere of the shields is "dry." The rocks are "dried out" rapidly with depth, and after 20-30 km beneath the surface there is virtually no free water. Since the mean

geothermal gradient here is low, it can be asserted that the lithosphere of the shields is relatively "cold": the temperature at the bottom of the earth's crust (level 40 km) does not exceed 400°C. These data, obtained in a direct experiment, immediately refuted the hypothesis of the possible existence in the territory of shields of conducting layers of a fluid nature situated at shallow depths in the crust. These data are used also in explaining some features of temperature and electrical measurements in the shaft of the super-deep borehole.

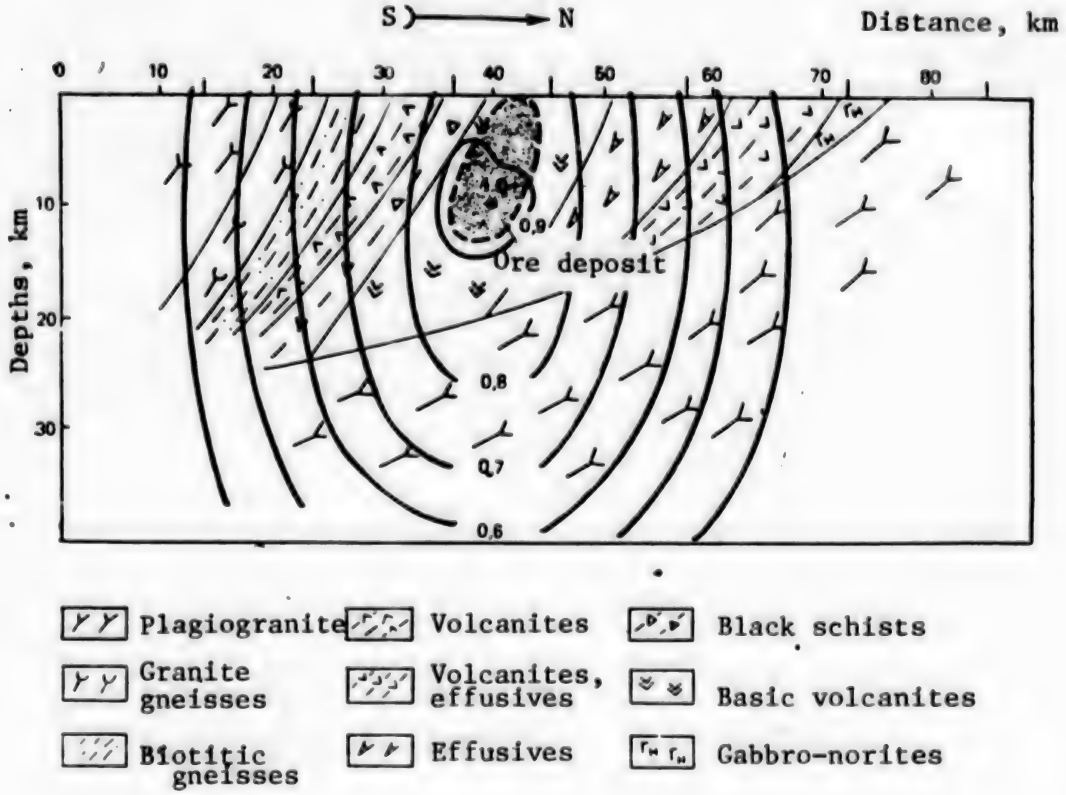
Interesting observations during the time of the experiment were made by specialists of the Polar Geophysical Institute, Kola Affiliate, USSR Academy of Sciences, and Terrestrial Magnetism, Ionosphere and Radio Wave Propagation Institute, USSR Academy of Sciences. They evaluated the effect of the "Khibiny" MHD source on processes transpiring in the ionosphere. For this purpose optical observations were made from an aircraft, magnetic variations were measured, vertical soundings of the ionosphere were made and studies were made of the reflection of short electromagnetic waves on ionospheric inhomogeneities by the incoherent scattering method. During an experiment in the ionosphere a local E-layer developed. Eight seconds after a pulse from the MHD generator this artificially generated layer decayed into two parts: the upper part rose vertically for 30-40 km, then it dropped down. All these successfully implemented observations indicated that artificial modification of the ionosphere is possible and this is of great importance for improving distant radio communication.

New Interpretation Methods

The abundant geophysical material obtained in the "Khibiny" experiment still cannot be considered final. Much work must still be done in different directions. The next goal of MHD soundings is the compilation of a three-dimensional diagram of conductivity in the earth's crust and a detailed study of anomalies which may well indicate presence of ores. Due to the coverage of great expanses with a constant positioning of the loop the electromagnetic field of the "Khibiny" source on the basis of the MHD generator can be regarded as a new geophysical phenomenon on a par with gravity and magnetic fields.

In essence the main purpose of the experimental studies is precisely an investigation of the spatial-temporal structure of the electromagnetic field of the MHD source at the earth's surface. The peculiarities of structure of this field reflect the peculiarities of the geological structure of the deep layers of the Kola Peninsula. A quantitative interpretation of electromagnetic data involves construction of a three-dimensional geoelectric model of the Kola Peninsula characterizing the vertical and horizontal changes in the conductivity of rocks. Such a formulation of the problem is fundamentally new for electromagnetic sounding methods because earlier in sounding work a study was made only of one-dimensional geoelectric models in which conductivity varies only vertically. In order to solve this problem effectively it is necessary first and foremost to develop mathematical methods for the modeling of electromagnetic fields in three-dimensionally inhomogeneous conducting media. Such work

has been carried out during recent years at IZMIRAN, at Moscow State University and at other organizations in the country. Mathematical modeling methods make it possible to write algorithms for the interpretation of electromagnetic data based on a purposeful choice of parameters for the geoelectric model.



"Geoelectric image" of section of Imandra-Varzuga structure along profile represented in diagram of block structure. The image was compared with the geological section. It is shown that the isolines of the migration field (in nominal units) outline an ore deposit.

It must be remembered that computations of each three-dimensional model still require a great amount of computer time (up to tens of hours) and, in addition, the success of the mentioned choice of parameters is dependent to a great extent on the apt choice of the initial parameters of the model. Therefore, during recent years theoreticians have devoted great attention to speedy methods for the interpretation of geophysical data, on a routine basis making it possible to obtain some initial idea concerning the geoelectric section of the earth.

Among such methods for example, is the method of migration of the electromagnetic field, which transfers the idea of optical holography to the case of the field of a MHD generator. As is well known, optical holography makes it

possible, on the basis of a hologram on which both the amplitude and the phase structure of the electromagnetic field is registered, to retrieve a three-dimensional image of the object. For this purpose it is adequate merely to illuminate the hologram with a coherent beam of light emitted by a laser (ZEMLYA I VSELENNAYA, No 3, p 17, 1984 -- Editor's Note). During sounding with a MHD generator at the earth's surface -- an enormous spatial "hologram" -- instead of light waves there was registry of the amplitude and phase of the electromagnetic field generated by the MHD source. The procedure of illumination of the hologram with a coherent light beam is replaced: at points on the earth's surface where the electromagnetic field sensors were situated there are fictitious "extraneous" sources of currents and charges whose intensities change in "reverse" time $\tau = T - t$ (where t is ordinary time and T is the interval of registry of the MHD signal) in conformity to a definite law.

The electromagnetic field generated by such fictitious sources (migration field), the same as in ordinary holography, forms the "geoelectric image" of the earth's deep structure. This method made it possible, in particular, to make a more precise determination of deep structure in the Imandra-Varzuga block which may well contain ores.

Thus, the use of the new technology for deep electromagnetic investigations -- powerful MHD generators -- required the solution of a large and complex group of problems ranging from the development of new models of electromagnetic measurement apparatus through the development of a special mathematical interpretation method. In this connection the results obtained in the "Khibiny" expedition indicate that the method of electromagnetic sounding of the earth with a powerful current source affords fundamentally new possibilities for deep geophysical research.

5303
CSO: 1865/100

INTERNATIONAL GEOLOGIC CONFERENCE IN MOSCOW

Riga SOVETSKAYA LATVIYA in Russian 3 Aug 84 p 4

[Article by Yevgeniy Kozlovskiy, minister of geology]

[Text] The 27th International Geologic Conference with some 5,500 geologists from 90 countries attending will be held in Moscow from the 4th to the 14th of August. The conference will consider topics such as world energy resources, mineral formation geology, engineering geology and hydrogeology problems and protection of the environment.

A country's geologic maps serve as indicators of its level of geologic research. Today nearly all of the territory of the USSR is covered by medium-scale (1:2,000,000) geologic mapping and nearly one-third of its surface is mapped in detail (1:50,000).

A comprehensive approach to the study of the earth's interior by geologic, geophysical and geochemical methods is one of the most important aspects in the dynamics of the geological sciences. New directions are opening up at a rapid pace. Oceanic and space geology are providing abundant material for the study of ocean and continent formation.

The most significant achievement of Soviet geologists in recent years has been the shift to a systematic study of the deep-layer structure of all territories in our country, the origin of which is assumed to be the drilling of the Kola and Saatly superdeep boreholes. Currently the Kola borehole is over 12 km in depth, while the Saatly in Azerbaijan is over 8.5 km deep. At these depths Soviet geologists got their first opportunity to study ancient Precambrian crystalline rocks. Superdeep boreholes will also be drilled in the Western Siberian, Caspian and Dnepr/Don oil and gas bearing regions, and in the Urals as well as in the Norilsk, Muruntau and Krivoy Rog mining rayons.

Thanks to the achievements of geologic science and the broad development of exploratory and survey work, a powerful mineral/raw material base has been established in this country supplying present national economic needs as well as those of future development. At present, our daily yield exceeds 600 million tons of oil, including gas condensate, 500 billion cubic meters of gas, 700 million tons of coal and 500 million tons of raw iron ore. Compared to 1940 levels, oil yield has increased 20-fold, gas 147-fold, coal over

4-fold, commercial iron ore production 8-fold and manganese ore nearly 4-fold. The Soviet Union is now one of the world leaders in the production of oil, gas, coal, iron and manganese ores and a variety of other mineral resources.

Satellite mapping techniques have been widely employed in geology in recent years. The conference will examine the topics of remote sounding in geologic mapping and mineral exploration and the use of geophysical field measurements from space for the purpose of predicting new oil-producing regions. Ring structures, first discovered on our planet by mapping from space, are attracting interest.

We consider the development of multilateral cooperation to be of extreme importance and participate in the activities of many international organizations. The most broadly organized of these is the cooperation of geologists within the framework of the CEMA, an especially large positive role is played by joint measures directed toward the resolution of fuel energy supply problems for member countries.

The Intermorgeo [Interseageo], Intergeotekhnika [Intergeotechnic] and Intergeoneftegaz [Interpetroleum] international coordination centers have been established to organize work on the most important problems. Significant results have been obtained in the course of Pacific Ocean expeditions with CEMA member countries.

The Soviet Union is not only a producer but also a major exporter of mineral resources. For example, oil and petroleum product deliveries from the Soviet Union satisfy 95 percent of Czechoslovakia's needs, 80 percent of Bulgaria and Hungary's needs and 75 percent of the German Democratic Republic's needs. In turn, these countries supply the Soviet Union with rolled ferrous metals, caustic soda and soda ash, chemical products and other raw materials.

The Soviet Union has concluded long-term agreements with many capitalist countries for the delivery of oil, gas, coal and other minerals. Through the "Gas--Pipline" contract, the countries of Western Europe have obtained a chance to improve their energy situation.

In speaking of international cooperation it is important to note that in recent years Soviet specialists have been conducting geologic surveying work in over 50 countries, where they have been able to assist in the discovery, survey or reappraisal of more than 1200 fields. With 15 other nations, our country is taking part in the development of the "Protection of the lithosphere as a component of our environment" scientific project, brought about by agreement between UNESCO, the UN Environmental Protection Program (UNEP) and the USSR. This problem is especially close to me since I serve as its scientific director and chairman of the international scientific advisory body. The ultimate goal of this program will be to develop and establish "lithomonitoring" as the only system for studying, predicting and

monitoring the condition of this geologic medium and changes in hydrogeologic conditions under the influence of economic activity.

Within the scope of various international organizations, work is underway on the production of geologic and other specialized maps covering major regions, individual continents and the world as a whole, as well as on the preparation of reports concerning the geology and mineral resources of Africa, Southeast Asia, the Middle East and individual countries.

Through United Nations organizations, the Soviet Union is assisting in the training of native personnel in the developing nations. In recent years seminars on modern exploration and surveying methods as well as the use of remote sounding data in geology and hydrology have been held in the Soviet Union for representatives of Asian and African nations. Many examples of successful cooperation on the part of the USSR can be cited, especially in the countries of Africa. These include phosphorite exploration in Morocco, the discovery of gold fields in Mali and the preparation by Soviet specialists of geologic and hydrogeologic maps of Africa, as well as maps of African continent mineral resources.

Broad cooperation is taking place along the lines of the UN, the International Association for the Geologic Sciences and other organizations carrying out fundamental research in various fields of geology with great practical significance. Soviet geologists are actively participating in the work of over 30 international geologic associations, commissions and committees, including the Commission for World Geographical Mapping, the International Stratigraphic Commission, the International Association of Hydrogeologists, the International Association for Engineering Geology and others.

International cooperation, including that in the sphere of earth sciences, helps to strengthen peace, is a concrete contribution to the positive development of relations between countries and facilitates the solution of various scientific and technical problems.

12746
CSO: 1865/80

EARTH'S RING STRUCTURES IMPACT MINERAL EXPLORATION

Moscow SOVETSKAYA ROSSIYA in Russian 10 Aug 84 p 3

[Answer to reader's question by Doctor of Physics and Mathematical Sciences O. Kuznetsov, director of the All-Union Scientific Research Institute of Nuclear Geophysics and Geochemistry in an article entitled "Drops from Below"]

> [Text] "I have often read about the ring structures of the earth's core. What are they and why are they attracting so much attention?" -- Ye. Murin, Kislovodsk

In the last 15 years ring structure formations have begun to appear nearly everywhere in geologic maps. These are ring-shaped geological formations in the earth's crust with diameters from 1 to 1,500 kilometers. They are found on the Russian and Siberian platforms, in Kazakhstan, the Timeno-Pechora region, on the Ukrainian, Aldan and Canadian shields, and even on the shelf of the Atlantic Ocean. These same rings and ovals have been noticed in great numbers on the surface of the moon, Mars and Venus.

There has long been disagreement over their origin. A number of scientists believe that they were formed by meteorite impacts. Indeed, objects from space have reached the planet over the course of many million years and these must have left their mark. If a meteorite some tens of meters in diameter were to strike the earth, the impact would be like an explosion. A crater would appear on the surface and rock would be strewn about the site in a ring shape.

Other specialists suggest that the responsibility for ring structures may not lie in outer space and that there are ample conditions for their formation here on earth. For example, volcanic action is one possible cause. It is known that volcanic eruptions lead to vast natural disasters which can leave traces in the form of rings.

All this is speculation. Here are the facts. Not long ago a large group of geologists--members of academic institutes and the Neftegeofizika [Petroleum Geophysics] scientific/production organization of the USSR Ministry of Geology--were issued a diploma for a discovery which explains the origin of ring structures. The authors demonstrated that they are formed by powerful forces from below, from the depths of the earth. From time to time the equilibrium of the earth's crust is disturbed by a floating body in the form

of a rising drop. The surface layers crack, circular or oval fissures are formed and these fill with mineral slurry. Here over time minerals, often having bright coloration, are formed. These also are indications of a ring structure system.

The determination of the origin of these structures has great practical significance, even in the search for valuable mineral formation.

12746
CSO: 1865/80

DEEP-DRILLING REVEALS MINERAL WEALTH

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 12 Aug 84 p 3

[Article by N. Konstantinov and Yu. Shevyakov]

[Text] There is not even a shadow of exaggeration in the wide-spread statement among geologists concerning a Ural peak once rich in iron ore: "It was a high mountain but it became a deep hole." This can now also be said of the until recently remarkable Magnit Mountain, as well as many Khibin hills and Altaic slopes erased from the geographical map by the shovels of open-pit excavators. Mine pits and boreholes are penetrating ever-deeper into the earth's interior. In the formations near Krivoy Rog for example, the extraction of iron ore has reached depths near 1 kilometer and surveyors are now evaluating reserves at the 2 kilometer level.

In the opinion of specialists, development at these depths, not to mention at the 5-10 km levels, will fundamentally broaden the possibilities for man's exploitation of the planet's raw mineral resources.

A special symposium was dedicated to this problem at the 27th International Geologic Conference where participants were especially interested in the report on the drilling of the Kola superdeep borehole which has passed the 12 km mark.

Unique material gathered from the Kola borehole is markedly expanding earth science capabilities for developing a theory of the planet's development and predicting mineral resource deposits in the USSR.

The Kola superdeep borehole has become the foundation of a broad program of research on the earth's core in this country. The program's most important element is the drilling of deep and superdeep boreholes in areas with different geologic formations. Successful drilling is underway at the Saatly borehole in Azerbaijan which will provide a clearer picture of the gas-bearing potential of the vast Kura depression.

Drilling is planned at the Tyumen borehole in the northern area of the Urengoy gas field, the Ural superdeep borehole in the copper pyrite and magnetite mineral zones and the Anastasyevaya-Troitskaya borehole in Krasnodar Kray.

Before 1985, this type of deep sounding will be initiated simultaneously at six other sites in this country. These will include the Dnepr/Don, Caspian and Timan-Pechora boreholes in petroleum fields and the Muruntau, Norilsk and Krivoy Rog boreholes in ore-bearing regions. The formation of a system of deep seismic sections is proposed in conjunction with the superdeep boreholes. A third component of the system will consist of geophysical data from aircraft and satellites. This comprehensive approach will allow the development of three-dimensional geologic models of various regions.

12746
CSO: 1865/80

12-KILOMETER KOLA SUPERDEEP HOLE AIDS GEOLOGICAL STUDIES

Leningrad LENINGRADSKAYA PRAVDA in Russian 22 Aug 84 p 1

[Article by I. Kapustina: "A Journey Inside the Earth"]

[Text] The new exhibits presented by the Central Scientific Research Geological Exploration Museum imeni Academician F.N. Chernyshev will assist in taking a journey into the earth.

For the first time one can view unique samples of ores from a section of the Kola borehole, the deepest in the world. Its depth has already reached 12 kilometers. For the first time in the world's experience, man has crossed the horizontal boundary that divides the "granite" and "basalt" lithosphere. The absolute age of the ores in the "granite" layer is estimated at 2.5-2.7 billion years.

The new exhibitions will assist in taking a journey into the Antarctic and will also familiarize one with the geological make-up and the mineral resources of the region adjacent to the Baykal-Amur Railroad, where the construction of the largest territorial-production complex is taking place.

12404
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ON THE PROGRESS OF ACCOMPLISHING THE COMPLEX SCIENTIFIC-TECHNICAL PROGRAMS OF THE USSR STATE COMMITTEE ON SCIENCE AND TECHNOLOGY IN INSTITUTION EARTH SCIENCES DEPARTMENTS

Alma-Ata VESTNIK AKADEMII NAUK KAZAKHSKOY SSR in Russian No 10, Oct 83 pp 4-5

[Text] The Presidium of the KaSSR Academy of Sciences notes that in accordance with the state five-year plan the KaSSR Academy of Sciences Institution Earth Sciences Departments are conducting research in accordance with the 11th All-Union Complex Scientific Technical Program for the USSR State Committee on Science and Technology. Under the 11th Five-Year Plan, within the framework of these programs, the institution departments will study 29 topics of which the Seismology Institute will have 12, the Geological Science Institute imeni K.I. Satpayev--4, the Mining Institute--7, the Hydrogeological and Hydrophysical Institute--2, and the Geographical Institute--1. Three topics will be developed jointly by the Geological Science Institute, the Hydrogeological and Hydrophysics Institute and the Geographical Institute.

In the Computer Hardware Program the Geological Science and Mining Institutes conducted research on three topics, one of which was completed in 1982.

At the Geological Science Institute the first automated scientific research system (ASNI) has been put into operation. At the Mining Institute the technical design for an ASNI automated experimental research system has been developed. The technical planning has been done and the methodology developed for the components of the Optimimum Stripping of Mining Areas Program.

The 10 topics in the Seismology and Earthquakeproof Construction Program are being researched by the Siesmology Institute which is the main organization in the country for the 2 problems encompassing the theoretical work on earth development tectonic mechanics and preparation for crust earthquakes. At the institute the mathematical theories for country rock creep and fold development in the upper levels of the earth's crust have been developed; the general theory of earth rotation is being developed; earth tectonic development mechanics has been created, and the central problem on crust earthquake preparation mechanics has been solved. A 1:25,000 scale map of the complex Alma-Ata seismological microarea and nearby territories has been produced. The savings from the introduction of this map in 1982 was 12 million rubles. A network was created from 8 hydrogeochmical stations which were the best equipped and organized for observation in the USSR. Broad experimental data were accumulated on the regular hydrogeochemical indications of earthquakes. The optimal design for the network of stations for observing powerful earthquakes has been completed for the immediate and foreseeable future.

In accordance with the two programs, Environmental Protection and Rational Use of Natural Resources, research on six topics is being conducted by the Geological Sciences Institute, the Hydrogeological and Hydrophysics Institute and the Geographical Institute.

A series of maps have been made up for the Aral Sea problem: the neotectonic northern Aral area structures, the Quaternary relief and broken ground, and the dynamics of the changing bedding and ground water mineralization depth in the Aral Sea during the period 1980-2020. A prognosis for change of the water-to-salt balance in the Aral Sea and its basin was given. A prognosis for the development of the national economic branches, population and work resources for the Kzyl-Orda Oblast to the year 2000 was presented. Maps of the neotectonic territory layout for the eastern Aral area and the geological and land reclamation layout for the Kazakhstan territory lying along the canal trace have been developed for the problem of rerouting Siberian rivers to Kazakhstan and Central Asia. Land suitable for irrigation has been determined, and the prognosis for negative effects has been made. Terrain charting of the reference sectors for the canal trace has been conducted.

Research on the three topics within the framework of the program Geology and Prospecting is being done by the Geological Science Institute imeni K.I. Satpayev. A dislocation process theory for Phanerozoic fold belts has been developed. The principal model for the tectomagmatic ophiolitic zone in Kazakhstan and its relation to plate tectonics have been determined. Central Kazakhstan Moho and Conrad surfaces have been mapped.

In the Operating Equipment Program research on two topics is being done by the Mining Institute. The scientific and technical principles for efficient operation of new robot solid ore miners have been developed.

The Seismology Institute is working on one topic of the Coal Industry Program. Methods for controlling cave-ins and soil swelling have been scientifically based, created and introduced in the Karagandaugol'Mine imeni V.I. Lenin Planning Department. Their introduction has saved 1,180,000 rubles.

As a result of the research under the 11th Five-Year Plan within the framework of the complex scientific and technical program, 14 monographs and symposia have been published by the institute departments.

The findings of the scientific institutions were regularly discussed at international, all-union and republic conferences and seminars with the participation of the leading scientific research institutions in the country and were highly praised many times. Due to this the Seismology Institute won the All-Union Socialist Competition in 1982 and was awarded the Challenge Red Banner by the USSR Academy of Sciences and the Central Committee of the Union for Workers at Educational, Higher Schools and Scientific Institutions.

On the whole, judging from the scientific research, work on the complex scientific and technical program is proceeding as planned.

The Presidium of the KaSSR Academy of Sciences presented information at the meeting on the activities of its institution Earth Sciences Departments on accomplishing the complex scientific and technical program and tasks of the USSR

State Scientific Technical Committee and committed the boards and leadership of the scientific institution departments to maintain primacy in financial, physical and personnel resources for accomplishing scientific research on the complex scientific technical program of the USSR State Committee on Science and Technology.

12747
CSO: 1865/252

PRESENCE OF ORE DEDUCED FROM GEOLOGICAL STRUCTURE OF NORTHEASTERN BALKHASH REGION

Alma-Ata VESTNIK AKADEMII NAUK KAZAKHSKOY SSR in Russian No 11, Nov 83 pp 42-43

[Excerpt from article by Candidate of Geological-Mineralogical Sciences D. Bekmagambetov: "Criteria for Presence of Ore in the Late Carbonaceous Intrusive Complex of the Northeastern Balkhash Region"]

[Excerpt] Geological-Structural Criteria

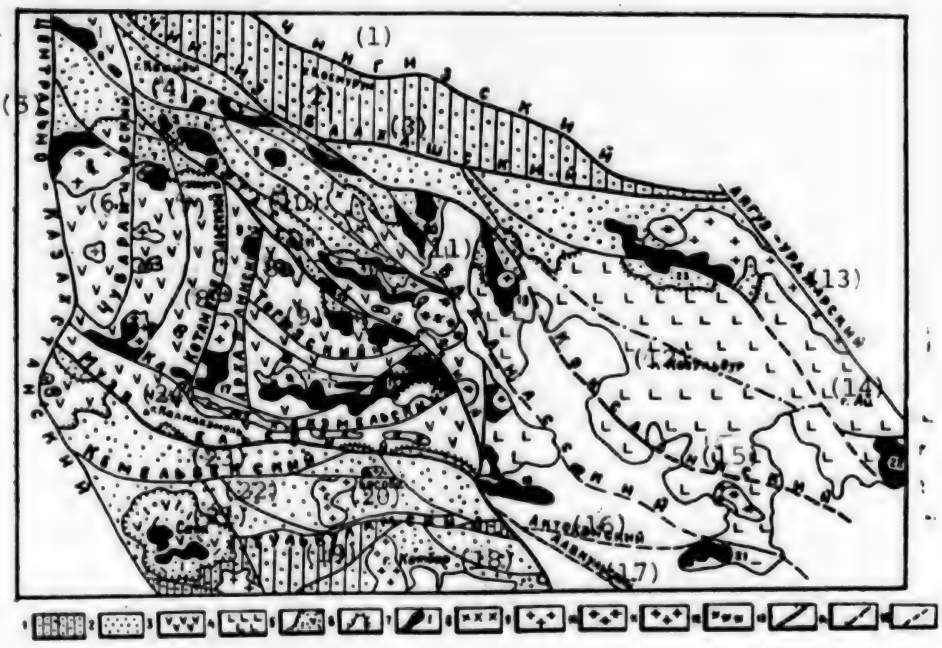

Diagram Showing Location of Intrusive Mountain Masses of the Northeastern Balkhash Region: *1-2*--rock mass outcroppings of the lower structural stage, (E_3—О—S—Д—C_1); *3-5*--rock mass outcroppings of the upper (orogenic) structural state; *3*--Kalamkemelskaya zone, *4*--Bakanasskaya zone, *5*--Sayakskaya zone; *6*--boundary of the upper volcanogenic structural stage; *7*--intrusive outcroppings of the Late Carbonaceous complex; *8*--intrusive outcroppings of the Early Carbonaceous

[continued on following page]

complex; *9*--intrusive outcroppings of the Late Carbonaceous, Early Permian complex; *11*--intrusive outcroppings of the Early Triassic complex; *12*--intrusive outcroppings of the Early Permian complex; *13*--faults established by geological, geophysical and aerospace research methods; *14*--faults established by data from space imagery; *15*--faults established by geophysical data

Key:

1. Chingizkiy
2. Mount Kosmorun
3. Chingiz-Balkhashkiy
4. Mount Kaindy
5. Tsentralno-Kazakhstanskiy
6. Chubaraycharskiy
7. Mount Zhorga
8. Kotanemelskiy
8a. Arkharlinskiy
9. Togyzskiy
10. Tasuyskiy
11. Bakanasskiy
12. Mount Koguldur
13. Ayaguz-Urdzharskiy
14. Mount Ay
15. Koksalinskiy
16. Aktoganskiy
17. Alakulskiy
18. Mount Katoar
19. Tulkulamskiy
20. Besova
21. Sayak
22. Kemelbekskiy
23. Muzbelskiy
24. Mount Kalmakemel

Rock masses occurring in the boundary zone between the essentially sedimentary flyschoid Devonian ($Д_2qv—Д_3fm$) and Early Carbonaceous (C_1t) deposits and volcanogenic formations of the Upper Paleozoic (C_1v_3-P_2) are the most productive with respect to copper-porphyry ore. These include Amanbay, Zhoba, Matay, Karabulak, Tassu, Zhaydaksu and Barmak. Mineralization in intrusive masses of this complex occurring in the upper orogenic volcanogenic stage is associated with rock masses localized in horsts and in uplifted anticlinal masses (Koldar, Zharyk, Kanzhaylau and Kiksu) related to the stage of tectonic-magmatic activation of the Hercynian folded structure of the Northeastern Balkhash region.

Ore mineralization is confined in these rock masses to portions of zones of maximum fracturing, and to the junctions of northwestern, sublatitudinal and northeastern fault systems.

The lithological and mineralogical composition of surrounding rock masses and the nature of their occurrence have significance. The most favorable among sedimentary rock types include medium-grained texture polymictic and calcareous sandstones, and carbonaceous siltstone-sandstone. Hornfels and skarn exhibiting vein-disseminated mineralization are well developed in them, for example in the rock masses of Zhoba, Matay and Tassu. Porphyry nappes of average basic composition are the most favorable among volcanogenic rock (the rock masses of Koldar, Kanzhaylau, Zaryk and others). The degree of exposure of intrusive masses is a factor of some importance. As a rule a significant concentration of minerals is not observed in deeply eroded rock masses.

Nor is copper-porphyry mineralization observed in plutonic masses in which gabbro-diorite-granodiorites are subjected to mineralization processes

producing potash feldspar and quartz, elicited by intrusion of later sub-alkaline granitoids.

11004
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ALL-UNION CONFERENCE ON HYDROGEOCHEMICAL INVESTIGATIONS CONDUCTED IN PROGNOSTIC SURVEY AREAS

Alma-Ata VESTNIK AKADEMII NAUK KAZAKHSKOY SSSR in Russian No 11, Nov 83 pp 76-77

[Article by I.K. Chepeleva, candidate of Physicomathematical Sciences]

[Text] The all-union conference "Hydrogeochemical Investigations in Prognostic Survey Areas" was held in Alma-Ata from 21 to 23 June of this year. It was organized by the Interdepartmental Council on Seismology and Earthquake Resistant Construction of the Presidium of the USSR Academy of Sciences, the Order of Lenin Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy of the USSR Academy of Sciences and the Institute of Seismology of the Kazakh SSR Academy of Sciences. The objective of the conference was to discuss the main scientific, methodological and practical problems of predicting earthquakes by hydrogeochemical methods, and to acquaint the participants with the work experience of the Institute of Seismology of the Kazakh SSR Academy of Sciences in the Alma-Ata prognostic survey area.

The conference was opened by Kazakh SSR Academy of Sciences Academician Zh. S. Yerzhanov, chairman of the organizing committee. USSR Academy of Sciences Corresponding Member V. L. Barsukov gave a plenary report generalizing the results of hydrogeochemical research in the USSR.

The conference proceedings were attended by 160 researchers from 21 institutes and organizations of Moscow, Alma-Ata, the union republics, Central Asia, the Transcaucasus, regions of Siberia and the Far East, Belorussia and the Ukraine, and representatives of scientific centers and affiliates of the USSR Academy of Sciences, the USSR Ministry of Geology and institutes, territorial administrations and production organizations of the USSR Ministry of Geology located in seismic regions.

Sixteen reports were given and 34 displays were discussed, devoted to the organization of work on the hydrogeochemical precursors of earthquakes in prognostic survey areas, to the behavior of precursors of different groups in Pacific geological conditions, to the methods of behavioral observations and statistical data processing, to the apparatus and problems of automating behavioral observations and data processing, and to the mechanism responsible for formation of the hydrogeochemical and hydrogeodynamic precursors of earthquakes.

A broad network of observations over hydrogeochemical and hydrogeodynamic precursors has been created in survey areas of Kazakhstan, Tajikistan, Uzbekistan, Kirghizia, Turkmenistan, Armenia, Azerbaijan, Georgia, Dagestan, the Ukraine and Moldavia, and in the Baykal, Kamchatka and Kuril-Sakhalin survey areas. This network includes 83 stations maintaining continuous and discrete observations over the chemical composition, temperature and discharge of water in 143 artesian wells and the water level in 97 wells. These observations are being conducted by organizations of the USSR Academy of Sciences, the academies of sciences of the union republics and the USSR Ministry of Geology.

The survey areas of the USSR have now accumulated many years of observations of variations in at least 40 components of the chemical composition of water associated with seismic conditions, and of general physicochemical and hydrogeodynamic indicators.

Hydrogeochemical research aimed at finding the precursors of earthquakes in the Alma-Ata prognostic survey area is developing successfully. The instrumentation and research organization of the network of hydrogeochemical stations that has recently been created makes it one of the best in the USSR.

Statistical treatment of data from behavioral observations has revealed the basic laws governing manifestation of hydrogeochemical and hydrogeodynamic anomalies depending on the physicochemical nature of precursors, the geological conditions of the region and the particular features of impending seismic events.

Research on the theory of hydrogeochemical precursors of earthquakes has enjoyed development in recent years. Mathematical models have been proposed for formation of hydrogeochemical anomalies; they account for the influence of various parameters, including kinetic factors.

Experimental simulation of the processes associated with formation of hydrogeochemical precursors deserves attention: large-scale modeling experiments in which large samples of rock are subjected to loads, artificial activation of rock-water-gas systems (including by experimental explosions, by subjecting the system to ultrasound and so on), and research on interaction occurring in the water-rock system in the course of formation of radon anomalies.

Mock-ups of automatic instruments to determine helium, radon, argon and nitrogen in thermal waters and instruments to determine the discharge, level, conductivity and temperature of thermal waters have been created. Automatic "Prognoz-1" instruments and automatic chromatographs used to analyze gas mixtures consisting of three to five components, including the "Rift-1" system, look especially promising for prognostic purposes. Modernized "Nayada" automatic water quality control stations, which record up to 10 physicochemical indicators of water, are also being used. Among the projects still under development, mention should be made of flow-through and flow-through-injection systems with ion-selective electrodes and nitrocellulose film detectors used for radon determination.

The methods of collecting, storing and processing hydrogeochemical data are being improved. Efforts to create data banks have been started. Algorithms for analyzing time series of observed parameters with the goal of isolating precusors have been proposed.

All research on hydrogeochemical precursors is being conducted in integration with study of geophysical fields.

The conference was conducted at a high scientific level. A resolution defining the prospects for further development of hydrogeochemical research methods used in earthquake prediction was adopted at its conclusion.

11004
CSO: 1865/227

MICROSEISM LEVEL, TIME VARIATIONS AT TURKMEN SEISMIC STATIONS STUDIED

Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKO-TEKHNICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK in Russian No 1, 1984 pp 77-81

[Article by B. S. Karryyev of the Seismology Institute of the Turkmen Academy of Sciences: "Research on the Microseism Level and Time Variations at the Turkmen Regional Seismic Stations"]

[Text] Determining the optimum conditions for the recording of seismic signals is an important procedural task in instrument seismology. For solving it it is essential to have information on the characteristics of the microseismic background (of the microseisms and seismic noise) at the observation point and their changes over time. Microseisms are a stochastic process and their spectral-time characteristics are formed by local seismogeological conditions at the recording point, by the medium on the path of propagation and by the sources. Experimental research in the range of 0.1-2 seconds makes it possible to divide them by the mechanism of formation into natural and anthropogenic [1, 2, 5]. The location of a majority of the regional Turkmen seismic stations in areas of human cultural activity has caused the prevailing effect of the anthropogenic seismic noise on the metering channels. For this reason there must be research on their characteristics and the detecting of the space-time features in the microseismic background within the system of regional seismic observations. The work has employed the data from the regional seismic stations and materials obtained in the course of special observations on microseisms in 1979-1982 [3, 4].

The recording of the microseismic background is continuous oscillations lasting without visible change for several hours. In recording with a broad-band channel, as a rule, clearly expressed basic harmonics are not established and this characterizes the signal as a broad-band one. A visual examination of the seismograms at stations located close to population points and industrial installations shows significant changes in the microseismic background level. For assessing the activity of the microseisms on the seismograms of these stations, we chose areas with the maximum amplitudes of oscillation and here we measured the amplitudes and their corresponding visible periods. In the aim of obtaining the time change in the amplitudes and periods, the measurements were made every other hour at 1-minute intervals. Statistically with a large number of measurements for each selected period, a cloud of values was obtained. The averaging of this provided a spectrum of noise amplitudes and this is the basic characteristic. Since the level of the microseismic background and its

frequency composition change over time, the values obtained over a large observation period should become the basis for constructing the average amplitude spectrum. In the aim of working out the observation procedure and processing the obtained materials, a study was run on the time changes in the maximum amplitudes and periods of the microseisms. The most informative for such research was the Ashkhabad Central Seismic Station [TsSS] located not far from the city (around 3 km). It is equipped with a short-period SKM-3 seismic device ($V = 6 \times 10^3$) and a SM-3 ($V = 15 \times 10^3$) located, respectively, in the station's cellar and in tilt-measuring whole at a depth of 25 m from the day surface. Here also is the narrow-band filtration unit consisting of a converter (located in the station's pit), preamps, filters for 15 and 30 hertz ($\Delta f = 0.2 \pm 0.05$ hertz), envelope isolating units and recorders which continuously record the high-frequency seismic noise. The metering channels have made it possible to study the microseismic background in a broad range of frequencies and times. It changes over the day (Fig. 1, a; 0200 hours at night and 1400 hours during the day). For describing the distribution of the periods and amplitudes of the maximum microseisms depending upon the frequency of their appearance (α), prismograms have been constructed (see Fig. 1, c) for the SVKM-3 channel. A comparison of the prismograms obtained at night (I) and during the day (II) show the stable distribution of the prevailing microseism periods. Regardless of the observation time, the maximum microseism amplitudes were timed to periods of 0.3-0.6 seconds. The statistical stability of the prevailing microseism periods (0.3-0.4 second) is obviously related to the seismogeological conditions in the given observation point.

According to the results of parallel around-the-clock observations by the standard SM-3 seismic channel and the narrow-band equipment, envelopes were obtained for the daily course in the maximum microseism amplitudes (A(t)) for the period of 0.3 second (SMG-3, N-S) and on the output of the narrow-band filters for 15 and 30 hertz (see Fig. 1, d; I-III). They showed the same time patterns for the change in the microseismic background and these are statistically stable for longer observation intervals (see Fig. 1, e). The calculation of the spectral density of the noise at frequencies of 15 and 30 hertz was made according to the formula [6] $S = \frac{2}{\pi \Delta f N} \sum_{i=1}^{N} A_i$, where $\Delta f = 0.2$ hertz; $N > 500$. In addition to the reduced noise level at night, the decline in microseismic activity is also characteristic for Saturdays and Sundays. The overall nature in the change in the microseismic background in the broad band of 0.1-1.2 second (the SVKM-3 and SGM-3 channels) and the narrow ones of 0.2 hertz (the 15- and 30-hertz filters) indicates that narrow-band filtration makes it possible to obtain sufficiently representative estimates which describe the behavior of the process in a comparatively broad band of frequencies. The discovered time patterns point to the anthropogenic origin for the basic part of the recorded microseismic background. However, this was not related to definite anthropogenic sources having a more local manifestation. Consequently, the microseisms existing at the given point are generated by a diffuse source (distributed over area) and which is the nearby city. The high inertia of such a source and the stability of the time changes in the microseisms generated by it are caused by the fact that the diffuse noise field is created by the entire aggregate of stochastic, independent vibration effects over a large area. Analogous patterns in the modulating of

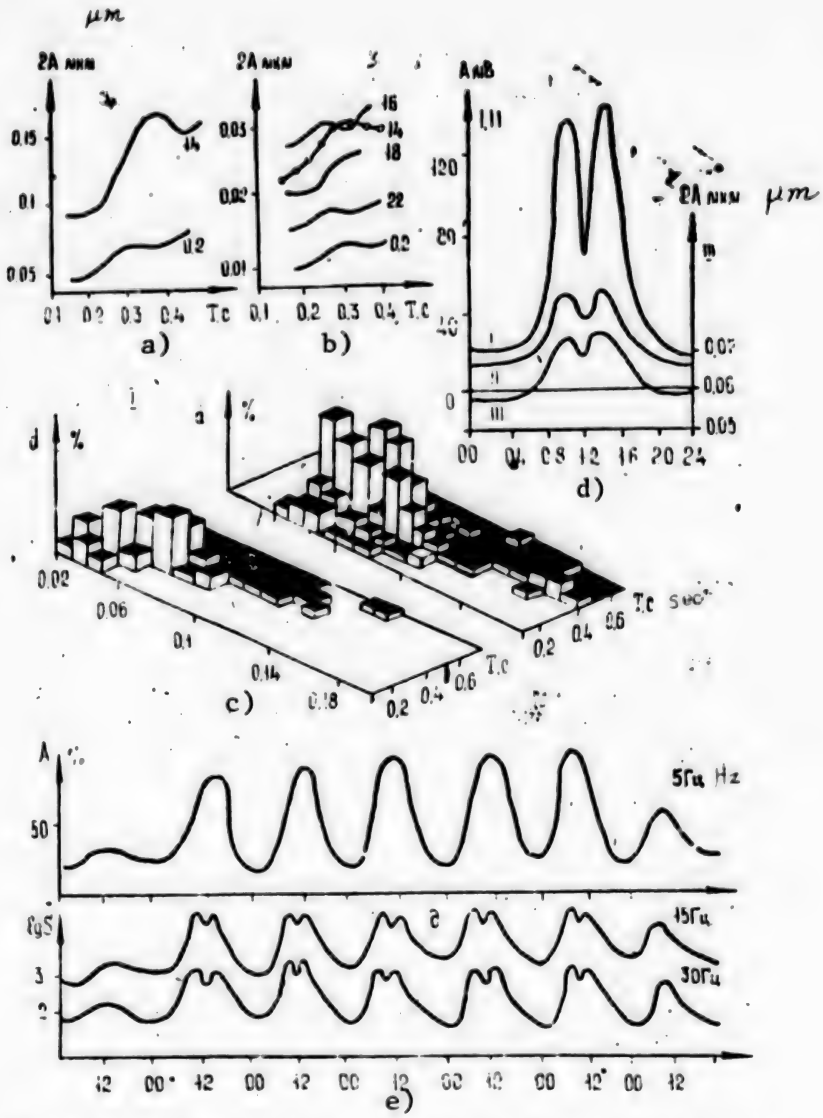

Fig. 1. Time Variations in the Characteristics of the Microseismic Background:
a), b) Change in the amplitude of the maximum microseisms at the Ashkhabad TsSS [Central Seismic Station] at the Gaurdak observation point; c) Prismograms for frequency of microseism appearance; d) Daily variations in microseism level at Ashkhabad TsSS; e) Envelopes of microseismic background at frequencies of 5 (III), 15 (I) and 30 (II) hertz.

the microseismic background by a diffuse anthropogenic source were also noted at a temporary observation point located 2 km from Gaurdak (see Fig. 1, b) and at a number of stations in the regional network. The stationary nature of the time variations in the anthropogenic microseismic background and the stability of their appearance close to large cities and industrial installations make it possible to assess the effective sensitivity of the metering channels using data obtained over a relatively short observation time. In viewing the anthropogenic diffuse source as a broad-band seismic emitter with periodically changing intensity, it is possible to point to its use for investigating the medium.

Table

Distribution of Microseism Periods at Observation Points, %

observation point	T, s									
	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
I	19	30	21,5	15,2	8,3	3,5	2,5	—	—	—
II	9,5	13,1	8,3	19,2	24,3	17,9	4,7	1,4	—	1,9
III	4,1	5,3	13,3	17,3	20,3	12,8	9,2	7,5	8,2	2,0

In the aim of disclosing the relationship of microseisms to the engineering and geological characteristics of the ground, in the area of the Germab Seismic Station, observations were made using a mobile seismic station. The vertical seismic detectors (SVKM-3) were set out as a triangle at a distance of 100-150 m apart and on different grounds: limestones (I), sandy loam with gravel (II), and heavily waterlogged loams (III). The seismic detectors were placed in shallow holes to avoid the direct effect of the wind. The signals from the seismic detectors were recorded simultaneously. From the results of the observations, tables were drawn up for the relative distribution of the microseism periods at the observation points. The distribution of the periods and the amount of the amplitudes in the microseismic background point to a definite relation with the different types of grounds (see the table).

For more solid ground (limestone), the distribution curve of the periods has one sharply expressed maximum (0.2-0.3 second) while on more friable grounds (the sandy loam with gravel and loams) the distributions are extended and have several weakly expressed maximums. At the point with the worst ground conditions (waterlogged loams), the microseism amplitudes intensify. At all points a decline was noted in the microseismic background level at night. Transport noise recorded at the points from a dirt road located approximately the same distance from them (up to 500 m) had the greatest amplitudes at points III and the least (around 25 percent of the recording at point III) at point I. All observation points were characterized by a statistical stability for the prevailing microseism periods regardless of the observation time.

Thus, for assessing the possible sensitivity of the metering channels it is essential to be guided by the following rules for determining the average amplitude spectra for the microseismic background.

1. The recording of microseisms is carried out for 3 days at maximum sensitivity in the required frequency range. The time of day with the minimum microseism level is determined and the possible cyclicalness is established for the time changes in the maximum background amplitudes.

2. In recordings with a maximum microseism level, for every other hour of recording there should be minute (for short-period metering channels of the SKM-3 type) runs which are free of earthquake recordings. In each of these the maximum microseism amplitudes and the corresponding visible periods (at least 50 measurements) are measured. The maximum microseismic fluctuations which norm the sensitivity of the metering channel are included in the processing.

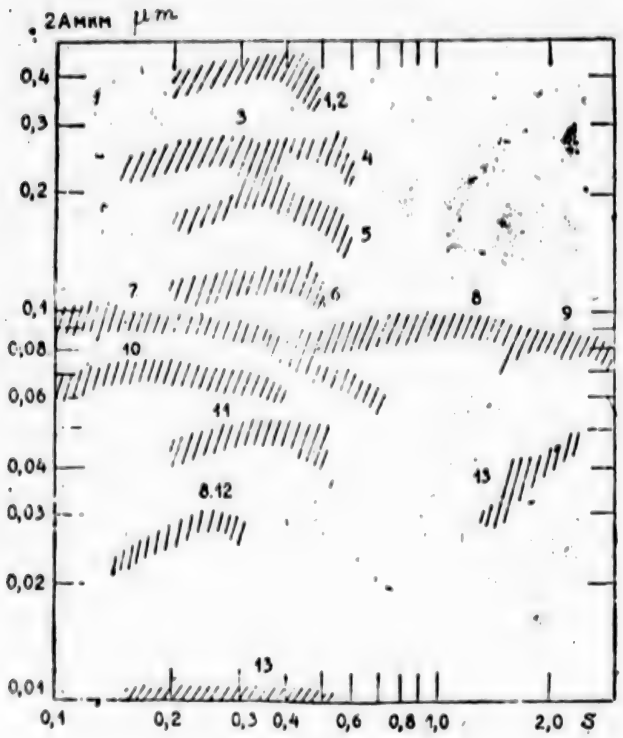

Fig. 2. Microseism Intensity at Turkmen Regional Seismic Stations: 1--Chardzhou, 2--Gyaurs, 3--Ashkhabad, 4--Karak-Kala, 5--Nebit-Dat, 6--Ovadan-Tepe, 7--Kaushut, 8--Krasnovodsk, 9--Kizyl-Atrek, 10--Manysh, 11--Chagyl, 12--Germab, 13--Vannovskaya

3. For constructing an average noise spectrum, a summary is kept for the data of the measurements made at moments of the maximum microseism level. The interval of discretization for the periods in compiling the cloud of values is determined by the accuracy of the oscillation resolution on the recording. After averaging the cloud values for the selected periods in the system of rectangular coordinates a curve of the amplitude spectrum is constructed. The calculating of the permissible increase and the choice of the optimum amplitude-frequency characteristics of the channel are analogous to those used in the work [4].

The microseismic background has been analyzed using this method at the regional seismic stations. The processing was carried out for the station seismograms. Recordings of the vertical seismic channels were used as the oscillation amplitudes are maximal on them. Using the results of processing for 1980-1981, a map was compiled for the distribution of the activeness of the microseismic background at the stations (Fig. 2). The calculation for the amplitude spectra of the tolerable increases for the stations conforms well to the established increase in the short-period equipment of the stations. In individual instances, regardless of the significant number of processed seismograms, at certain stations it was hard to obtain a statistically reliable result due to the heavy insensitivity of the metering channels. The use of the mobile station increased the accuracy of the estimates. An analysis of the distribution of the microseismic background shows uniformity for a majority of the region's stations (see Fig. 2). This was caused by its anthropogenic origin and by the similar seismogeological conditions at the observation points.

Conclusions

A study was made on the time variations in the microseismic background at the Ashkhabad TsSS and these pointed to the anthropogenic origin of its basic part. The influence of ground conditions on the amplitude-period characteristics of the microseisms was assessed. The stationary nature of the time variations in the anthropogenic microseismic background and the constancy of their appearance close to large cities make it possible to employ this for investigating the medium. A method was proposed for determining the average spectra of the

microseismic background and a map was obtained for the distribution of the maximum microseisms at the regional seismic stations.

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10272
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GENERAL MODEL OF EARTHQUAKES AND THE PLACE OF WARNINGS IN IT

Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKO-TEKHNICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK in Russian No 1, 1984 pp 64-70

[Article by O. A. Odekov of the Turkmen Polytechnic Institute]

[Text] In studying the nature and mechanism of a majority of natural phenomena it is essential to solve the inverse problems, that is, from the end result of the effect to recreate the initial model. In particular, the presence of various, at times contradictory, models for the preparation of earthquakes has been caused precisely by this circumstance. At the same time, it is obvious that there should exist a single general model for the preparation of earthquakes, in other words, their general theory which logically includes several particular models (theories) which do not contradict one another but on the contrary complement one another. The diversity of existing models objectively reflects the exceptional difficulty of resolving this problem while subjectivism in the understanding of the cause-and-effect phenomena further aggrevates this situation.

Up to now several general models have been formulated for the development of earthquakes and we will examine the essence of these in chronological order. These models are based either on a study of specific earthquakes or on some individual parameters of the geological medium considering the achievements of modern science.

According to the model of H. F. Reid [21] based on a study of the California Earthquake of 18 April 1906, the earth's crust in moving continuously during the period leading up to the earthquake began to obstruct this movement. The obstruction was limited and the deformations caused by it die out as one moves away from it. At the last moment, the obstacle collapses and a source of seismic waves arises, that is, the center of the earthquake.

Thus, in the model of H. F. Reid, one can establish three stages: the accumulation of the strain energy, the disruption of the normal course of movement in the earth's crust in a local area expressed in the development of an obstacle to this continuous movement, and the destruction of the obstacle, that is, the occurrence of an earthquake.

In the energy model of the seismic condition of Yu. V. Riznichenko [16], without describing a model for the development of an individual earthquake center, the processes comprising the seismic condition are examined for a large part of the earth's crust and for a significant interval of time. The leading role in the process of the development of an earthquake is played by the potential strain energy accumulated by the medium and the strength of the rock which varies over time and is also determined by the energy indicator. Here the earthquake is related to the effect of the reduced strength of the medium caused by the formation, growth and coalescence of microcracks for local zones of increased plasticity.

Thus, in the model of Yu. V. Riznichenko, logically one can establish two stages: the accumulating of the potential strain energy in a large volume of the earth's crust and over a significant time interval and the reduction in the strength of the rock in a limited volume of the medium, the result of which is a strong earthquake.

In the general model of I. P. Dobrovol'skiy [7], the process of the development of an earthquake is viewed as the process of the rise and development of a certain discontinuity (inclusion) of the medium's physicochemical properties localized around the center of the future earthquake (first phase), the breakdown of this discontinuity (second phase) occurring by the end of the first phase, when the discontinuity reaches a critical instable state, its breakdown commences with a reduction in the accumulated potential strain energy and the return of the medium to a state close to the initial. The second phase in the given model is, in turn, divided into two stages--the foreshock and aftershock separated by the moment of the earthquake. Finally, the third phase (the phase of quiet) is a period of a background state and which is marked by the quiet nature of the seismic processes. Here under certain conditions in the model of I. P. Dobrovol'skiy, the aftershock stage immediately moves to the development of a new earthquake and then the third phase is absent.

In addition, the inidividual phases are characterized by the duration of their occurrence. Thus, in the first phase this can exceed by several fold the time of occurrence of the warning signs which has been empirically determined by some researchers, while the warning signs during this phase are considered long-term and merely show the development of a discontinuity. The foreshock stage, in being considered as the first part of the second phase, in terms of duration is scores of times shorter than the first phase and the warning signs in it are considered as short-term and are the consequence of the already commenced destruction of the discontinuity.

Thus, a review of the general models for the development of earthquakes shows a substantially different approach by the researchers to the resolution of this problem. Objectively this is the consequence of the ignorance of the mechanism and nature of the processes occurring at the center of the earthquake. For this reason, the most hypothetical part of all the existing models, like incidentally the one proposed by the author, is the notion of the first stage (or phase) in the development of an earthquake. For precisely this reason with the present level of acquired data, an analysis of the process of earthquake development, that is, a description of its general model, must be considered the reverse problem of geotectonics, while earthquake forecasting from warning signs is the

direct problem and not vice versa, as certain researchers feel [20]. At the same time, without reliably knowing those processes which occur in the first stage in the center of an earthquake we now know rather well all the remaining subsequent stages of this process. This makes it possible to work out a general model for the process of the occurrence of an earthquake and establish the place of the warning signs in it on a new qualitative level based upon a new class of tectonic movements in the earth's crust discovered by the author.

In works by foreign and Soviet scientists, a relationship of earthquakes has been posited "with rapid movements in limited parts of the earth's crust" [18] or "oscillations of the earth caused by the sudden release of the deep potential energy of the earth" [6] and so forth. In all instances, when it is a question of earthquakes of tectonic origin (95 percent of the total number of earthquakes), various authors link them to movements along faults or to the avalanche-like growth of anticlines, and in relation to this the seismogenic faults and zones are established [6, 13]. However, prior to the appearance of the works [1, 11] there was no other work where, in classifying the tectonic movements, an independent taxonomic unit was established for the class of tectonic movements generating earthquakes, with a precise and definite description of this by the nature of their appearance (vertical and horizontal), for period, amplitude, place and area of their coverage and frequency of occurrence.

The essence of the given effect is that in the earth's crust and upper mantel acting together are vertical and horizontal tectonic movements which are caused by the forces of tension and compression and causing movements in the earth's surface during the periods which precede the earthquakes as well as at the moment of earthquakes [1, 11].

An earthquake develops deep in the earth over an extended time while at the center of the future earthquake there is an increasing tension on the rock. The latter increases not only at the focus of the earthquake but also at the epicenter and in the future epicenter and (or) pleistoseistic zones. Here the closer the focus is to the earth's surface and the greater the energy of the future earthquake, the higher the strain on the rock and the joint synchronous, anomalous deviation caused by the rock in the component of vertical and horizontal tectonic movements at the epicenter, the epicenter and (or) pleistoseistic zones of the developing earthquake during the periods proceeding the latter and during it. In other words, the increased tension on the rock in the earth's crust and upper mantel causes the formation of an unusual class of tectonic movements which are termed seismic-generating [1].

The seismic generating tectonic movements are a special class of tectonic movement arising in the earth's crust and upper mantel during periods preceding earthquakes and during earthquakes and are caused by the joint action of tension and compression forces characterized by a great amplitude and short periods of intervals of appearance in time. The seismic generating tectonic movements against the background of the modern flow secular movements of the earth's crust are marked by an abrupt increase in amplitude (by modulus) initially by 5-6-fold and at the moment of the earthquake exceeding their values by scores of fold and more. Another essential feature of the seismic generating tectonic movements is the compulsory joint synchronous appearance of both the vertical and horizontal component of the tectonic movements before the earthquake.

Thus, a general model for the development of earthquakes as proposed by the author is a model of the development and manifestation of seismic generating tectonic movements. In it a logical place will also be given to a majority of the known basic warning phenomena and these will be viewed in a new light, without contradicting the previously established facts.

The first phase in the development of an earthquake is the constructive or evolutionary. The time of its occurrence exceeds the time of occurrence of all subsequent phases taken together by 1-2 magnitudes and more. In this phase the development of the earthquake occurs. As was already pointed out, notions about this are the most hypothetical part of the proposed model. However, data obtained over the last two decades on the deep structure of the earth's crust for individual regions of the earth make it possible to voice certain new considerations on the nature of earthquakes.

Thus, in studying the abyssal structure of the tectonically active regions of Turkmenistan on the "granite-basalt" boundary, the existence of shallow layers with an anomalous speed was discovered (O. A. Odekov, O. K. Vasov, A. Yuvshanov, 1975). It turned out that the depth of the foci of the strong earthquakes in the Ashkhabad seismic-prone area coincide with the depths of occurrence of the designated strata. The latter circumstance made it possible later [10] to voice the opinion that these strata are in a strained state and are sources for the occurrence of earthquakes.

Previously B. Gutenberg (1957) pointed to the existence in the lower parts of the "granitic" and "basaltic" strata of the earth's crust comparatively shallow strata with reduced propagation speed of the longitudinal waves. Moreover, in analyzing the data of seismic methods Yu. N. Godin [5] pointed to the existence of strata with an anamolously low rate in the earth's crust of Southeastern Turkmenistan (1957) and on the southeast of the Russian Platform (1956-1957). The presence of such strata in the earth's crust of southern Turkmenistan was confirmed [4] by data obtained by the method of earthquake transformed waves (METW) and by the data of seismic logging in deep wells in the sedimentary beds in the work areas of the METW. According to the METW data, in the eastern part of the Ciskopetdat Downwarp across its strike several strata have been established with anomalously reduced values for the propagation rate of the transverse wave. The number of "anomalous" areas in the earth's crust increases as one approaches the mountain structures of Kopetdag and in the sections these have been established as a sedimentary strata and as a consolidated part of the earth's crust.

Thus, in order not to broaden the question by drawing on analogous data for other regions of the world, it must be said that up to the present a multilayered, heterogeneous nature of the earth's crust structure has been shown with the presence in it of anomalously low-speed strata with thicknesses that are less in comparison with the covering and underlying normal-speed strata.

In comparing these facts with data on the confining of the foci of earthquakes to strata with anomalously reduced speeds, it can be assumed that unknown physicoprocesses occur in them and as a result these cause the occurrence of earthquakes. Probably these strata are in a state of an unstable equilibrium and the disrupting of this is expressed by earthquakes. For example, granites under

certain thermobaric conditions lose the crystallization water and come close to basalts in density, while maintaining their former physical composition. These rocks are called granulites and they represent a different stage of metamorphism than do granites. Similar processes can also be one of the possible mechanisms for the occurrence of earthquakes on the "granite-basalt" boundary.

In this phase one can scarcely speak of the manifestation of any clear warning phenomena, with the exception of the concluding frames of the given phase in which it is possible to have a regularly abrupt or, in the words of modern physics and dialectical materialism, a continuous-discontinuous transition to the second phase of earthquake development and, consequently, the beginning of the appearance of certain warning signs.

The second phase is the reconstructive or intermediate. There is the rather widespread opinion that strong earthquakes develop and occur differently from weak ones. This idea obviously is correct is one speaks of the duration and scale of appearance of the earthquake warning signs. Thus, the duration of the manifestation of the seismic generating tectonic movements over time depends upon the intensity of the developing earthquake, running from tens of days (3-4-point earthquakes) to scores of months (8-12-point earthquakes).

The second phase in the development of earthquakes is the basic one in the sense of the warning manifestations. At the given phase for strong and catastrophic earthquakes it is possible to isolate several time categories of their warning signs. Here the seismic generating tectonic movements are apparent in all the time intervals but with varying intensity depending upon the force of the developing earthquake and the distance from its epicenter. In other words, the seismic generating tectonic movements are universal warning signs of earthquakes over time.

In the second phase it is possible to establish four time categories for the earthquake warning signs: long-term, medium-term, short-term and day-to-day. In addition, in terms of spatial manifestation or length of action, by analogy with the time classification, the warning signs for strong and catastrophic earthquakes can also be divided into four categories: wide-scale, medium-scale, small-scale and local. Like the time manifestations, the seismic generating tectonic movements are recorded in the entire spatial range and thus in this sense are also universal warning signs.

For sensible (6-7 points) and weak (4-5 points) earthquakes there will be a different ranking of the spatial and time warning signs: for the former, obviously, the first group of space-time warning signs will be absent, that is, the broad-scale and long-term ones, while for the latter also the two first warning ranks of broad-scale, medium-scale and long-term, medium-term.

The dividing of the warning signs by scale of appearance (in space or range) and in time makes it possible to clearly determine the place of each warning sign in their general series and establish which of them is of fundamental and practical significance and which are merely of purely theoretical, scientific knowledge, without being an independent method for earthquake forecasting.

Moreover, such a classification makes it possible to establish which of the warning signs is a direct reflection of the earthquake development process and which are determined by subsequent causal phenomena. In other words, it is essential to ascertain both the simple as well as the complex cause-and-effect relationships and only then can one clearly establish the position of each warning sign of the earthquake and its real possibilities for forecasting. This problem can be carried out in greater detail on the basis of setting up particular models of earthquake development but here we will merely determine their place in the general rank of warning signs.

World practice knows only several instances of the successful predicting of earthquakes, and for this reason a majority of the known warning phenomena has been established not on the basis of specific instances of earthquake prediction but rather is related to these post facto. It is possible to count around two-score warning signs, 15 of which were divided by T. Rikitake [17] by observation methods while the remainder were added on the basis of later recorded inventions and discoveries in this area and for this reason were not in his summary. A review of certain warning signs from the positions of the appearance of seismic generating tectonic movements and cause-and-effect relationships with the given class of tectonic movements indicates that tilts, ebb tides of the sea, subsidences and uplifts recorded by surveying methods and related to earthquakes, similar to the hydrogeodynamic (HGD) effects [10], are the consequence of the appearance of one of the components (the vertical) of the seismic generating tectonic movements.

The deformations of tension and compression recorded by strain meters, the tensions discovered by geodimetric observations and the relative increase in the area of the rhombus disclosed by measurements on a rhombic base level--all of this is the consequence of the manifestation of the second of the components (horizontal) in the seismic generating tectonic movements.

Changes in the geomagnetic field and manifested in its reduced tension and magnetization are the consequences of compression [17]. At the same time, all the listed, so-called warning signs may also not be such and like the HGD effects, can be the consequence of aseismic processes (movements along faults, including creep type, slides, aseismic tilts and so forth). For this reason, by measuring one of these parameters it is impossible to judge about a pending earthquake. For precisely this reason in the sparse register of successful forecasts there is not a single one predicted by just one of the designated warning signs. In further determining the place of the other warning signs in the process of the second phase of earthquake occurrence, it can be said that some of them are related in terms of spatial manifestation to small-scale and local ones (geochemical, gravimetric, electrical, deformation, acoustic and other). In terms of the time of manifestation, a portion of the warning signs is among the short-term (foreshocks) or day-to-day, that is, manifested over days (for example, acoustical) and hours (biological). Moreover, a majority of the known forecasting methods do not take into account the migration of earthquake foci in space and time and for this reason they cannot be used since the warning parameters appear only above the focus of the earthquake and observations are carried out, as a rule, over the foci of previously occurring earthquakes. Finally, the use of certain warning signs is virtually impossible to purely technical and economic considerations due to the need for continuous, around-the-clock measurements or

the impossibility of automating the measurement process and, consequently, obtaining express information on the warning signs.

Thus, the prevailing majority of presently used warning signs is not of independent practical significance for earthquake prediction and can be only of scientific interest, supplementing the range of nonuniversal methods and earthquake warning signs.

The earthquake prediction method based on recording the class of seismic generating tectonic movements is devoid of all the designated shortcomings and is independent and universal [1]. At the same time, such a statement would seem like an empty declaration if it were not backed up practically, since precisely practice is the criterion of truth. The confirmation is the forecasting of the weak (5-point) earthquakes which occurred on 21 and 24 February 1982 in the area of the settlement of Vannovskiy (the Ashkhabad seismically active area), when in December 1981, some 25-30 km from the epicenter they observed an anomalous synchronous joint increase (in comparison with the background) in the vertical and horizontal components of tectonic movements which foretold these earthquakes (detailed results of these works were given in the collective work).

Thus, precisely the second phase in the process of earthquake occurrence is the basic one in the manifesting of warning signs and in the future, in forecasting the time of an earthquake [1], an opportunity will appear to artificially effect the developing destructive and castrophic earthquakes, in gradually releasing their force and energy and thereby nullifying the damage [11].

The third phase is the destructive, revolutionary one and is expressed by the earthquake. This phase is instantaneous (from seconds to several minutes) and in terms of area covers the territory where the seismic generating tectonic movements spread, being its concluding chord.

At the moment of the earthquake, the seismic generating tectonic movements are marked by a sharp rise in amplitude (for modulus), exceeding their background values by scores and more fold. The third phase ends precisely with the strongest jolt in the entire series of earthquakes.

The fourth phase has been called relaxation or concluding and for catastrophic, strong, sensible and even in a majority of instances for weak (5-point) earthquakes this is expressed by aftershocks. The mechanism of occurrence of aftershocks in strong earthquakes, the sequence and intensity of their manifestation have been studied rather satisfactorily [14, 15, 22]. In each series the aftershock of the greatest energy is significantly weaker (by a magnitude of 2-3) than the main jolt and even the total energy of the aftershock series is just 10 percent of the energy of the main jolt [14, 15].

Retrospective statistical analysis of repeat earthquakes occurring in different seismogenic regions of the world uniformly shows the existence of the following pattern: after the first earthquake, the second and all subsequent ones (if they occur) happening over a certain time interval, in terms of strength and intensity are not stronger or even, as a rule, are weaker than the first jolt. In turning to analogies, this pattern can be compared with the work of a mathematical pendulum: the amplitude of the pendulum's first swing to one side is

approximately commensurate to the swing to the opposite side, in gradually declining thereafter.

Thus, in the fourth, concluding phase, there is the final drop or the relaxation of the strains expressed in the aftershocks. The duration of this phase depends upon the intensity and force of the main earthquake, running from several days to several years.

Conclusions.

1. A general model has been worked out for the process of the occurrence of earthquakes on the basis of a class of seismic generating tectonic movements with the establishing of the place of warning signs in this.

2. The discovered new class of tectonic movements and the method of earthquake forecasting realized on the basis of this as an invention are the foundation for a deterministic approach to their forecasting.

3. The proposed method of earthquake forecasting is universal both in terms of time as well as for force and place.

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10272
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SUPERDEEP DRILLING PROGRESSES IN USSR

Moscow DOMESTIC SERVICE in Russian 0800 GMT 15 Jun 84

[Text] Eleven boreholes will be sunk under the program for superdeep drilling being carried out in the Soviet Union. Two of them--the Kola borehole and the Saatly borehold in Azerbaijan--are already operational. Their depths have exceeded 12 and 8 km respectively. The implementation of the program has been discussed at a coordinating conference of scientists and specialists which has been held in Baku. At the conference it was noted that the Kola and Saatly superdeep boreholes had become extremely valuable scientific laboratories. The data which have been obtained have made it possible to update many ideas about the depths of the earth derived from geophysical information. This makes it possible to search for mineral resources in a more purposeful manner. Sinking of two more boreholes, in the Ukraine and Kazakhstan, began this year. Preparations are in hand for the drilling of the Kuban and Tyumen boreholes, in oil and gas regions, and the Urals, Krivoy Rog and Muruntau (Uzbekistan) boreholes in ore provinces. They will be started during the current five-year plan. Altogether 150 scientific research institutes and enterprises, representing 15 of the country's industries, are taking part in the implementation of the integrated program for superdeep drilling, which will last until the year 2000.

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EARTHQUAKE FORECASTING RESEARCH IN THE UKRAINE

Kiev VISNYK AKADEM'YI NAUK UKRAYINS'KOYI RSR in Ukrainian No 2, Feb 84
pp 105-107

[Article by V.V. Kutas and G. Ye. Kharechko, candidates geological-mineralogical sciences: "Development of Seismoprognostic Research on UkSSR Territory: Fourth Science Council Session, UkSSR Academy of Sciences, on the Question of 'Modern Geodynamics and Forecasting of Earthquakes' in Kiev"]

[Text] Earthquake forecasting is an important national-economic problem the solution of which will help to avoid significant material losses and human sacrifice caused by this terrible natural phenomenon. That is why investigation and study of those phenomena which can predict earthquakes is so urgent.

Last year toward the end of September, the republic's Fourth Science Council Session of the UkSSR Academy of Sciences was held at the Department of Earth Sciences AS UkSSR in Kiev on the problem of "Modern Geodynamics and Earthquake Forecasting." Scientists and specialists of academic institutes participated in the session: geophysics, applied mechanical and mathematical problems, geological sciences, geology and geochemistry of combustible copaline, and hydromechanics; Departments of Geography and Gravimetrics of the Institute of Geophysics, Poltava Observator AS UkSSR; Mineral Resources Institute of the UkSSR Ministry of Geology, Kiev State University; Lvov Polytechnic Institute of the Main Administration of Geodesy and Cartography at the USSR Council of Ministers; and a number of production associations of the Ukrainian SSR Ministry of Geology. Representatives of Belorussian SSR were invited to the session.

Completed research studies for 1983 were summed up and plans for research in 1984 were examined during the work of eight sections.

At the planning and section meetings, 46 scientific reports were made addressing the most important problems of modern geodynamics and earthquake forecasting. Section directors reported on the research findings and the direction of their development.

Research on deep lithosphere structure in the earthquake regions of the Ukraine and its adjacent territories--one of the most urgent problems--was presented in a report by the collective of collaborators from the Institute of Geophysics

imeni S.I. Subbotin under the direction of A.V. Chekunov, academician of the UkSSR Academy of Sciences, and V.B. Sollogub, corresponding member of the UkSSR Academy of Sciences. Analyzed here were the complex interpretations of seismic depth sounding data, seismology and other geophysical methods--gravimetry, magnetometry, geothermy along the V international traverse. This geotraverse interesects the Vrancha region--seismically active zone of deep-focus Carpathian earthquakes where twice in the last 40 years catastrophic earthquakes where sustained, which in western Moldavian SSR and in south-western Ukrainian SSR reached an intensity of 8 and 7. The sustained detailed vertical fracture of the lithosphere to the top of the asthenosphere is of significant interest for the analysis of the deep structure of the seismogenic part of the Carpathean region and the adjacent area.

The section leader on deep lithosphere structure, Corresponding Member AS UkSSR V.B. Sollogub, outlined the main directions of the research for the accountable period: the reinterpretation of deep seismic sounding material from II-VI geotraverses based on the overall analysis of geophysical materials, the folding schemes of fractures on Ukrainian territory and the water areas of the Black Sea, Caucasus, and Bulgaria, and carrying out of new field observations.

R.I. Kutas, doctor of geological-mineralogical sciences, reported on the research carried out on the nature of geological zones and their variations in Carpathian and Crimean mountains. To show areas of anomalous changes in geomagnetic field, research was carried out in the Carpathian geodynamic polygon territory to study the age-old movement on the sections lying transversely to the eastern sweep of the Carpathian slope and the seismic zone of the Transcarpathian rift. Routine observations were continued on geomagnetic field variations at three Transcarpathian points and on temperature changes in three boreholes situated within the boundaries of Beregivs'kiy's seismicity zone. Near the Yalta zone of dangerous seismic activity, in the Crimean polygon, there is a continuously operating magnetometric station and observations were conducted on the geomagnetic signal (T) at 60 points situated on three sections which intersect the Gorno Crimean zone of seismic activity.

The results of the study on changes in stress conditions in the environment of seismogenic zones in the Ukraine, by recording the variations in geochemical and hydrogeological fields, were described by O.P. Isychenko, candidate of geological-mineralogical sciences. The study revealed that some variations in hydrogeochemical parameters depend on endogenous factors, and the first stage in adapting the investigation findings on variations in hydrodynamic system and geochemical composition of subterranean waters was carried out. Regular cyclical variational elements were taken into consideration associated with the phenomena of moon-sun tides and climatic factors, against the background of which an attempt was made to find a useful signal--an earthquake predictor. Emphasis was placed on the development of seismotechnical analysis methods in order to predict the time of earthquakes with a goal to create a model of deformational structure of seismogenic zones and identify regions of maximum concentration of stress contact.

Candidate of physical-mathematical sciences B.G. Pustovytenko reported on an important achievement--development of a method to study signs of strong earthquake formation through distance-time frequencies of weak shock foci (centers) by analyzing the seismic conditions in the Crimean region. Information criteria were evaluated for forecasting strong earthquakes by recording changes in the distance of the epicenters of weak shocks. The proposed method makes it possible to evaluate the strength, place, and probable time of a future earthquake. Prognostic deductions were made based on retrospective calculations of distance-time distribution of weak earthquake epicenters during the formation period of strong earthquake. A potential region of seismicity was identified in Crimea where, according to prognostic findings, the "squeezing" action process of epicenters of weak shocks is being completed and can manifest itself, in the nearest two years, in a magnitude of 5-0.5, that is with an intensity of 6-7. The method was tested in forecasting the Crimean earthquake on 28 March 1983, whose parameters are within the limits of our forecasting appraisal. Twenty other seismically related signals associated with the preparation of the above-mentioned earthquake were investigated, which support the reorientation of the local stress field and change in the character of surroundings and seismic behavior of the future focal zone.

The work and major achievements of the section on the mechanics and physics of earthquakes were presented by the deputy director of that section, T.Z. Verbytskiy, candidate of geological-mineralogical sciences. The mathematical modeling of elastic resilient waves was examined under nonlinear elastic conditions. The characteristics of seismic wave interaction with the zone of the forming earthquake focus were demonstrated and also new wave effects that may appear with the exposure of focal zones. A method was developed for the determination of elasticity-deformation conditions in the focal zone under a given tectonic dislocation based on numerical modeling of the focus at the appearance of the rift which begins to form.

Timely studies on current geodynamics of the earth's crust in seismogenic zones, geomorphodynamics of geotectonic structures and their reflection in relief and activity in the Neogene-Quaternary Period were presented in reports by geomorphodynamics and geodynamics section heads R.P. Kuprash and I.V. Somov, candidates of geological-mineralogical sciences.

Geodetic work was continued on the study of recent movements within the boundaries of the Carpathian geodynamic polygon on standard natural sections which intersect the Transcarpathian fracture. The raised limb of the folded part of Carpathian mountains was recorded for the period of 1977-1983 in relation to the regional Transcarpathian deep fracture zone. Research directed at the study of neotectonic structures was carried out; a study was conducted on the range of differentiation of recent alluvial sediments in the valleys of major rivers. Station observations were conducted on the exogeneous processes of the polygon's local sections. In the territory of the Crimean geodynamic polygon, in order to study the distance-time progress of recent vertical and horizontal folding movements of the earth's crust, a geodetic polygon was created in Demerdzhinskiy's deep fracture. The findings of neotectonic research showed that in the southern part of the geodynamic polygon, complex differential movements occur; the interconnection of exogenous and endogenous processes was established.

One of the most important problems in the formation of forecasting techniques is the development of new types of equipment for general investigation of variations in different natural fields in the geodynamic polygons. At the section meetings reports were heard on a series of critical points which arose in the process of developing the equipment.

Material submitted by the collaborators of the Institute of Applied Mechanics and Mathematics of the AS UkSSR evaluated the findings of the testing of a borehole variant for continuous geoacoustic monitoring of the stressed-strained state of mountain mass rock. The main features of a block diagram of a digital automatic station were analyzed for the first time. This was created to study microearthquakes; also discussed was the developed automatic system for transmission of routine investigation findings on the polygons along electrical connection lines. Special features of building amplifier units were considered, as were analog-digital (computer) conversion and the main principles of information analysis of the digital automatic station, as well as a series of other questions.

Summing up the session's work, A.V. Chekunov, academician of the UkSSR Academy of Sciences, emphasized the solid achievements of the past year in the modern geodynamics and earthquake forecasting field; forecasting methods were developed based on the findings of seismological investigations and the study of natural geophysical, geochemical, hydrogeological fields; and specific types of equipment necessary for regular observations were developed. A.V. Chekunov underscored the pressing need to finally resolve the question about the organization of all the points for routine observation in the Carpathian mountains and Crimea.

12598
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NEW DATA ON PRESENCE OF ORES IN SALT DOME STRUCTURES OF DNIEPER-DONETS BASIN

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA B: GEOLOGICHESKIYE, KHIMICHESKIYE I BIOLOGICHESKIYE NAUKI in Russian No 9, Sep 84 (manuscript received 30 Nov 83) pp 3-5

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[Abstract] There are more than 300 salt domes in the Dnieper-Donets Basin. In approximately 1/10 of them hydrothermal mineralization of different types, such a mercury, lead-zinc and barite, has been discovered. More than half of these ore shows have been found in the southeastern part of the basin, but this may be due to inadequate exploration of other parts of the basin. This article gives new data on the ore content of salt domes in the central part of the region obtained in recent mineralogical-geochemical investigations. Magnetite and an accompanying association of high-temperature minerals was detected, for example, in a borehole at depths of 5,080-5,500 m. The vast majority of salt dome structures containing ores are found in a broad zone of a deep fault extending through the entire axial part of the basin. For this reason there is a whole series of salt dome structures in this zone which warrant careful exploration. The salt domes of the greatest practical importance are those in which the cap rocks, hypothetically the ore-bearing zones, are situated at relatively shallow depths. Promising sectors of this type are salt dome structures in which the cores of the diapirs break through the above-lying sedimentary deposits of pre-Paleogene and pre-Upper Permian age. There is new evidence suggesting the possibility of detecting new ore shows in the peripheral sectors of the region. Figures 1; references: 2 Russian. [110-5305]

UDC 550.822(571.1)

DEEP STRUCTURE OF WESTERN SIBERIA

Moscow SOVETSKAYA GEOLOGIYA in Russian No 5, May 84 pp 75-85

KARUS, Ye.V., GABRIELYANTS, G.A., KOVYLIN, V.M. and CHERNYSHEV, N.M., Neftegeofizika (Petroleum Geophysics) Scientific-Production Association

[Abstract] The article gives a generalization of data from seismogeological sections for clarifying the morphological characteristics of the principal discontinuities in the earth's crust in Western Siberia. This area is covered by 19 deep seismic sounding profiles with a total extent of 17,000 km. Two principal discontinuities exist: Mohorovicic discontinuity (Moho) and consolidated crust (CC). The Moho is at depths of 34-50 km, characterized by boundary velocities 7.9-8.7 km/sec. The CC is at depths 4-10 km with boundary velocities 6-6.6 km/sec. The position of the CC boundary, like the Moho, is not constant; the amplitude of their depths is up to 3 km. Other reflecting and refracting discontinuities can also be discriminated in the crust. Figure 1 is a map of Moho relief; Fig. 2 is a schematic seismogeological section of the crust and upper mantle in the region; Fig. 3 is a corresponding velocity model of the crust and upper mantle; Fig. 4 is a map of CC relief; Fig. 6 is a map of crustal thickness between the Moho and CC discontinuities. In the morphology of the Moho and CC discontinuities there is a rather rigorous vertical zonality: uplifted or subsided blocks at the Moho correspond to approximately the same blocks at the CC discontinuity, but with reverse representation in the relief. Figure 6 shows that about 80 percent of the petroleum, gas and gas condensate deposits occur in the central region which has specific characteristics in comparison with other parts of the platform. Most of these deposits are in zones of maximum fragmentation of the crust. Since the results are based exclusively on deep seismic sounding data they must be considered preliminary and data from other seismic methods and other geophysical fields may modify the generalization presented in the article. Figures 6; references: 17 Russian.
[214-5303]

UDC 550.3:551.241

MODEL OF EARTHQUAKE MECHANISM

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 28, No 6, Jun 84 (manuscript received 17 Aug 83) pp 550-553

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[Abstract] In an earlier study (DAN BSSR, Vol 26, No 4, pp 358-361, 1982) the author described the mechanism of generation of horizontal stresses and movements of the crust under the influence of traveling tidal deformation waves. The tectonic mechanism outlined in that study has now been investigated using a laboratory model simulating discrete wave movement of a layer of a deformable

body under the influence of a traveling deformation wave and periodic displacements or "jumps" of parts of a body when there are elastic couplings to a support. The earlier study, supplemented by the laboratory experiments, give what appears to be a clear picture of the fundamental physical aspects of the mechanism of accumulation and release of shearing stresses and discrete movements of crustal blocks. For example, the model simulates the genesis of horizontal movements of a layer of an elastic body, the gradual accumulation of elastic energy caused by a slow increase in tangential forces and stresses the crust and the elasticity of rock masses subjected to the influence of these forces (an increase in stresses occurs under conditions of uniform rotation of the earth and is unrelated to centrifugal forces or other dynamic phenomena), the process of periodic displacements (jumps) of elastic layers coupled by mechanical cohesion and frictional forces to a supporting surface (a simulation of the elastic release process now accepted as the basic earthquake shear mechanism), the influence of the physico-mechanical properties of rocks and their cohesion with the underlying surface, the magnitude of rock movements during earthquakes and the influence of lubrication by fluid present between the contacting layers of terrestrial rocks on the shear mechanism of stressed rocks. It becomes clear that an earthquake is a jumplike process of return of terrestrial rocks to their normal state after a prolonged period of stresses. Figures 1; references: 8 Russian.
[230-5303]

UDC 550.34

STATISTICAL FILTERING AS METHOD FOR DETECTING TRANSCRUSTAL ACOUSTIC ANOMALIES

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA B: GEOLOGICHESKIYE, KHIMICHESKIYE I BIOLOGICHESKIYE NAUKI in Russian No 4, Apr 84 (manuscript received 28 Jun 83) pp 17-20

OROVETSKIY, Yu.P. and YAVLOCHKINA, L.M., Geophysical Institute, Ukrainian Academy of Sciences, Kiev; UkrGIPRONIINeft' Institute

[Abstract] Transcrustal acoustic anomalies were first discovered in the area of the Ukrainian shield. These are regions with an enhanced capability for generation of exchange waves or sectors where reflecting elements are seldom registered. These anomalies have the form of a funnel or overturned truncated cone. They can be traced to a depth of 70 km and can be extrapolated to a depth of 120 km. These regions emerge from the upper mantle, intersecting the entire thickness of the crust. At the tope their width is 70-160 km and at the base 20-80 km. The Moho is uplifted in such areas relative to its position in surrounding areas. The gravity field is a broad gently sloping minimum, often complicated by insignificant positive anomalies. The basis for discriminating transcrustal acoustic anomalies is the nonuniformity in the spatial distribution of both exchange points and reflecting elements within the limits of different geological structures. In order to make these inhomogeneities stand out it is necessary to eliminate the regional background. The authors propose a statistical filtering method for accomplishing this. The practical application

of the method is described. Previously it was possible to detect transcrustal acoustic anomalies only in regions of intensive surface magmatism. The statistical filtering method can now be used in detecting "blind" deep magmatic diapirs over which metasomatic aureoles can be expected. Figures 2; references: 9 Russian.
[226-5303]

UDC 550.361

INTERPRETING GEOTHERMAL ANOMALIES BY SPECIAL POINTS METHOD

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSSR, SERIYA B: GEOLOGICHESKIYE, KHIMICHESKIYE I BIOLOGICHESKIYE NAUKI in Russian No 4, Apr 84 (manuscript received 24 Jun 83) pp 13-16

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[Abstract] The interpretation of heat flow anomalies is usually accomplished by constructing a theoretical curve which is as close as possible to the observed curve, an approximate, time-consuming procedure, although feasible when an electronic computer is used. This article describes a new, alternative approach involving the discrimination of special points which are then used in determining the parameters of the disturbing object. This method has not really been used in the interpretation of heat flow anomalies because the theoretical possibilities of the method have not really been explored. The method is developed in this article, as an illustration by an examination of a nonstationary heat flow field of a cooling, infinitely elongated prism. A study was made for bodies of different extent for a broad ragne of change in cooling times. The horizontal derivative of the heat flow is found and the coordinate of its maximum is determined. With this as a point of departure it is shown how nomograms can be constructed on the basis of the heat flow anomaly for rapid determination of the horizontal extent L and time of onset of cooling of the infinite prism in the entire ragen of τ and L. Having this procedure for interpreting heat flow density anomalies, it is easy to develop a method for interpreting temperature anomalies. Figures 2; references: 3 Russian.
[226-5303]

UDC 556.314(574)

METHOD FOR DETECTING PROMISING ORE SECTORS USING HYDROGEOCHEMICAL DATA

Alma-Ata VESTNIK AKADEMII NAUK KAZAKHSKOY SSR in Russian No 10, Oct 83 pp 34-39

DAVLETGALIYEVA, K.M., candidate of geological and mineralogical sciences

[Abstract] The ground water in different ore regions of Kazakhstan differs considerably in its content of genetic groups of elements, this constituting a basis for defining different types of hydrogeochemical associations which can be used in exploration for different types of ore bodies. Data are given

for a series of ground water sampling points in Kazakhstan which are then used in illustrating the procedures developed in the article for the detection of promising sectors. One of the first steps is the preparation of a series of hydrogeochemical maps to be used as working documents, such as a hydrogeochemical zonality map showing the mineralization and quality of ground water and a predictive hydrogeochemical map showing the microcomponent composition of ground water in different territories, together with the pertinent hydrogeological associations of elements and their fields, as well as sectors of hydrogeochemical anomalies. The types of hydrogeochemical associations were defined in earlier publications of the author. However, many other steps are involved in reliable defining of hydrogeochemical anomalies associated with known or hypothetical ore bodies. Three categories are used for the selected key ore element: background, corresponding to the clarke by a factor of 1.5-2; anomalous--exceeding the background by a factor of 2-2.9 or 3-4. The multiple correlation and factor analysis methods are used in the processing and generalization of hydrogeochemical materials. Factor analysis, rarely used before in hydrogeochmical studies, was found to be particularly effective. Although the set of proposed factors complicates determination of the boundaries of an anomalous sector, procedures are suggested for overcoming the difficulties. The summation of factors approach was especially effective. Figures 2, tables 2; references: 5 Russian.
[251-5303]

UDC 553.689.041(574.5)

SOUTHERN KAZAKHSTAN AS BARITE RAW MATERIAL BASE OF COUNTRY

Alma-Ata VESTNIK AKADEMII NAUK KAZAKHSKOY SSR in Russian No 10, Oct 83 pp 16-20

YUNUSOV, B.I., OVCHINNIKOV, V.V., MIROSHNICHENKO, L.A., LOZOVETS, V.Ya., KUZNECHEVSKIY, A.G. and TURSUNKULOV, E.T.

[Abstract] With respect to the reserves and production of barites Kazakhstan plays the leading role in the USSR. Until recently about 75 percent of the barite concentrate in the republic was produced at the ore enrichment plants at Kentau, but their production has now dropped off. Little exploration work for barite has been done in southern Kazakhstan until recently. However, medium- and large-scale surveys made there have now revealed widespread occurrence and enormous potential reserves of this raw material. A map was compiled which shows promising regions for finding barite and proven barite reserves. The most favorable areas for expanding proven reserves are in the Central and Northwestern Karatau. The next most important region for reconnaissance and exploration work is the Chiganak area. In case of necessity the barite ores in this region could be worked from the surface. At the same time detailed exploration work should be carried out in the Zhaysan area which has an exceptionally favorable geographical and economic location; monobarite raw material could be exploited here for meeting the needs of the cement industry. A table gives the distribution of barite reserves in different regions of southern Kazakhstan. This area is capable of meeting the needs of the national economy for this short-supply type of raw material for many decades to come. Figures 1, tables 1.
[251-5303]

PHYSICS OF ATMOSPHERE

LIDAR UNITS DEVELOPED AT ATMOSPHERIC OPTICS INSTITUTE

Frunze SOVETSKAYA KIRGIZIYA in Russian 4 Oct 84 p 4

[Excerpt] At the Tomsk Institute of Atmospheric Optics of the Siberian Branch of the USSR Academy of Sciences, new models of laser locators, or lidars, are being developed. They are finding applications both in scientific research and in the solution of many tasks of economic importance.

Academician Vladimir Zuyev, director of the institute, commented: "The laser beam has become an effective instrument for the study of atmospheric processes. Studies of the atmosphere with the aid of lidars are included in the environmental-protection program which is an important part of the super-program 'Sibir'' (Siberia)."

Zuyev showed some of the apparatus in the special design bureau of scientific instrument building "Optika", where scientists' ideas are put into real objects.

Anatoliy Soldatov, head of the department of quantum electronics, described a three-color laser beacon called the "Liman". It uses a quantum generator that operates on vapors of copper and gold. It functions almost like a traffic light. A green light means: "Hold your course." Yellow and red lights warn ships that they are straying off course.

And there are the lidars--special laser systems whose beams help gather information about the atmosphere. The lidar is a whole instrument complex, a kind of scientific laboratory which includes a laser device, instruments which record information, and computers for processing the information.

FTD/SNAP
CSO: 1865/102

RESEARCH SHIP 'VIZE' AND OTHERS END POLEX STUDIES IN ATLANTIC

Leningrad LENINGRADSKAYA PRAVDA in Russian 30 Sep 84 p 1

[Article by A. Kozlovskiy]

[Text] Five scientific research ships have completed another phase of "Poleks-Sever" (Polex-North) studies, which are being conducted in line with a program of the USSP State Committee for Science and Technology.

The scientific research ship "Professor Vize", the flagship of the expedition, has returned to Leningrad. Its crew handled the gathering, processing and transmission of hydrometeorological information from all of the ships.

The purpose of the studies was to investigate the intensity of the exchange of water through the Faroe-Shetland and Faroe-Iceland straits, which are the main channels by which warm Atlantic waters enter the Central Arctic Basin, and also to study ocean waters in places where cyclones form.

Observations of the sun's radio emissions and of oil pollution of the ocean also were conducted on the "professor Vize".

The studies in oceanology, hydrochemistry, hydrography and aerometeorology were directed by specialists of the Arctic and Antarctic Scientific Research Institute, the USSR Hydrometeorological Center and other scientific institutions. The results will be used in compiling long-range weather forecasts and in studying fluctuations of climate in the Northern Hemisphere.

FTD/SNAP
CSO: 1865/102

SCIENTISTS ARRIVE IN ANTARCTIC FOR 30TH EXPEDITION

LD291232 Moscow TASS in English 1151 GMT 29 Oct 84

[Text] Leningrad October 29 TASS--An IL-18D Aeroflot air liner, which left Leningrad with the participants in the 30th Soviet Antarctic expedition six days before, arrived at the "Molodezhnaya" Observatory in the south polar Enderby land on Saturday.

The most difficult section of the transcontinental route was over the Indian and southern oceans, in a zone where no permanent meteorological observation is ensured, but Soviet meteorological observations are being made. The Soviet meteorologists precisely calculated weather conditions all over the more than 5,000-kilometer long route between Maputo, the capital of Mozambique, and the Antarctic. The flight was proceeding at an altitude of 8,500 meters, in cloudy weather but with a fair wind, Anatoliy Khokhlov, the flight director radioed.

In the course of November, the IL-18D will make several shuttle flights on the Molodezhnaya-Maputo air line and bring to the white continent a total of nearly 250 researchers and experts. Regular flights of Soviet expeditions to the Antarctic have become routine after a snow-ice airfield, the world's only, was built at "Molodezhnaya" station to handle heavy transport planes. Similar airfields are under construction at a number of other observatories and stations flying the Soviet flag.

CSO: 1865

SATELLITE PHOTOGRAPHS SUGGEST ARCTIC VOLCANO

Moscow IZVESTIYA in Russian 31 May 84 p 6

[Interview with Yu. Masurenkov, Institute of Volcanology, by O. Dzyuba; date and location not given]

> [Excerpts] The satellite photographs clearly showed a huge cloud, a foggy trail extending more than 200 kilometers over the northern Arctic Ocean. What is it, the eruption of an unknown volcano? But after all, man has never before observed anything like it in the far north of the planet. And now satellites have recently again sent to earth signs of violent spurts of internal activity in these latitudes. A special expedition has been organized at the DVNTs [Far Eastern Scientific Center] of the USSR Academy of Sciences to investigate the arctic phenomenon.
>
> Yu. P. Masurenkov, its director and chief of the laboratory for ground volcanism, answers some questions by IZVESTIYA.

[Answer] Bennett Island, where the satellite registered the anomalies, is located near an intense zone of seismic activity. It takes in the Aleutian Islands and Kamchatka, passes along the bottom of the northern Arctic Ocean and joins the Middle-Atlantic Ridge. And the link between seismic activity and volcanism is well-known.

Any geography textbook mentions the volcanos of Kamchatka and the Aleutian island ridge. In the northern Arctic Ocean, "North Pole," one of the drifting stations, also noted phenomena that remind one of the eruption of an underwater volcano. We consulted representatives of practically all scientific institutions that are working beyond the Arctic Circle. But as before, it was not possible to explain what happened other than to say that it was volcanic activity. It would simply be unforgiveable not to look into the satellite data. In August of last year, the expedition of the Institute of Volcanology, which I was entrusted with leading, left for Bennett Island.

Without the assistance of K. Chubakov, chief of the Northern Sea Route Administration, and F. Polynin, chief of staff for maritime operations of the eastern section of the Northern Sea Route Administration, the expedition would hardly

have been successful. A preliminary examination of the scrap of land lost in the ice and a preliminary investigation from the air were without results. If the volcano had been there, it had clearly calmed down by this time. Alas, we were not able to find any visible traces of the recent eruption on the island. But do not forget that the photographs from space were dated February, and we were on the island in September. During this time, arctic blizzards could very well have covered over the effects of the eruption.

Geological samples from the island were encouraging. Without a doubt, volcanic processes are no rarity for Bennett Island. Mountain rocks on the island have undergone considerable change under the influence of geothermal waters. That means that hot springs have bubbled up there relatively recently.

We found some surprises below the surface of the water. On the bottom we found an underwater cone with a diameter of about 4 kilometers and a height of 10 to 15 meters. Such volcanic "pancakes" are well-known on Kamchatka, and they are also found in Iceland. In similar eruptions, there is almost no emission of ash, but, on the other hand, there is a great deal of lava. That means that there might be a foggy trail above the sea that a satellite could notice.

There is still another interesting underwater discovery. Samples taken from the bottom of the East Siberian Sea turned out to be similar to the sediment that falls out of contemporary thermal waters. They form extremely slowly in the ocean. One millimeter is deposited in a million years. But here that process took place catastrophically rapidly.

Finally, we discovered the most mysterious thing during laboratory processing of the materials. Depth measurements have already been taken near Bennett Island. When we compared our own diagram with the old map of the bottom, it turned out that the underwater cone had grown considerably during the past years. In addition, a noticeable "excrescence" appeared on it that reminds one very much of a huge lava field. Meanwhile, new photographs arrived from space.

The mysterious trail was noted again in November 1983 and after that in March and April 1984. It was for this reason that the decision was made at the Institute of Volcanology to organize a new expedition.

Who knows, it may be that this question will be solved in the coming months.

9746
CSO: 1865/60

30TH TIME TO ANTARCTIC

Leningrad LENINGRADSKAYA PRAVDA in Russian 15 Aug 84 p 4

[Interview with Ye. S. Korotkevich, Arctic and Antarctic Scientific-Research Institute, by N. Orlov; date and location not given]

> [Text] In the near future, the 30th expedition will leave Leningrad for Antarctica. Preparations for it are in full swing. Ye. S. Korotkevich, doctor of geographical sciences, distinguished polar explorer, Hero of Socialist Labor, and deputy director of the Arctic and Antarctic Scientific Research Institute, tells about the most important results of the research on the sixth continent in recent years and about the tasks of the 30th SAE [Soviet Antarctic Expedition].

More than 15,000 Soviet people have already been on the sixth continent. Of these, more than 5,000 have participated in winter expeditions. We have built 13 long-term stations and 8 temporary and seasonal stations in Antarctica. Some of them were closed after the implementation of the work program. At the present time, observations are performed throughout the year at seven stations.

The rich and often unique materials of the antarctic expeditions are processed at almost 40 scientific research institutions in the country. During these years, more than 70 volumes on the work and more than 100 issues of the INFORMATSION-NYY BYULLETEN' SAE have been published, and the world's first "Atlas Antarktiki" was published in two volumes. This work was awarded the USSR State Prize. As a supplement to the "Atlas," more than 300 sheets of maps of the continent and about 100 sheets of maritime charts were issued.

[Question] What new things have scientists learned about the weather and climate of the icy continent?

[Answer] Thanks to Soviet research and extensive international scientific cooperation, we have received important information on Antarctica's meteorological regime and its influence on the planet's climate. Here is just some of the information: the atmosphere over the continent is exceedingly clear, and its mass is little more than two-thirds as great as that over the Arctic, and therefore the cold air does not spread as readily to neighboring regions; the atmospheric circulation is more active over the coastal zone, and here

there are almost always raging winds, the velocity of which reaches 60 meters per second and more; Antarctica gives off tremendous quantities of moisture into the atmosphere.

An important task was and remains the study of the interaction of the ocean, atmosphere and continent in quantitative terms. This is essential not only for the development of more precise weather forecasts but also for long-term forecasts on climatic change.

[Question] Has the time come to think about the development in Antarctica of extractive and processing sectors of industry?

[Answer] I will say right away that throughout all of these years geologists were involved in overall geological research and they solved important scientific problems. Among them were the investigation of the structure of the crust of the entire earth and its reforming and the development of the hypothesis about the continent of Gondwana, the key to the understanding of which lies in Antarctica. It must be stressed in particular that neither in the initial years nor now have we had the special goal of searching for useful minerals. But in studying the structure of the depths of the continent, we found coal, iron and copper-molybdenum ore and signs of several other valuable and useful minerals.

We believe, however, that the time has not yet arrived to open up this continent on an industrial scale. In the first place, it is too harsh and dangerous and people have not yet learned to create such comfortable conditions there for living and working as exist in other regions of the earth. Secondly, no single country possesses a technology that would be completely harmless for the natural environment of Antarctica that is so difficult to recreate.

[Question] The sixth continent is called the planet's refrigerator. Can it be said that glacial research was and remains part of the basic research?

[Answer] Soviet scientists determined with great reliability the volume of "preserved" ice in Antarctica. It turned out to be 24.9 million cubic kilometers. If it were to melt suddenly, the water level in the world's oceans would rise by 60 meters. Quite a lot of other interesting data have been obtained on the antarctic glacial mass. For example, it turned out that it has several domes, the highest being more than 4,000 meters in the central area of the continent. The continent has frozen rivers that are extensions of glaciers. The coast is more than half surrounded by shelf glaciers, huge plates of floating ice.

Glaciologists were also interested in questions of the structure of the thickness of the glacial mass and the processes taking place in it. A depth boring was begun at the station Vostok. It is now down more than 2,000 meters. Calculations and observations permitted the conclusion that in the central parts of Antarctica the ice is continually melting at its fundamental base. There are now reasons to think that there are fresh-water lakes under the ice.

[Question] How does the program of the 30th expedition differ from that of the preceding expeditions?

[Answer] The basic directions that were developed all of these years--aerometeorology, the study of the ocean, glaciology and geology--will be retained in the coming expedition. A relatively new area of research is the ecology of the continent. In the first years of opening up Antarctica, when there were very few people there, this was not a real problem. Now, when thousands of people from many countries remain on the continent even over the winter, and with prospects of tens of thousands in the future, the ecological situation is becoming much more acute. All those who come to the continent try to settle on spots that are not covered with ice. And there are exceedingly few such places, as only 0.5 percent of the entire surface area of the continent is free of ice. The time has come to think seriously about how to save the original world of these territories and about how to preserve the pristine natural environment of Antarctica.

[Question] Will scientists and researchers work under international programs?

[Answer] At the end of the 1970's, a special period began in the life of Soviet antarctic expeditions, a period of research in extensive complex and international programs. This includes POLEKS YUG, the International Glaciological Antarctic Project; the Soviet-American experiment "Polyn'ya" [Ice Hole] in the Weddell Sea; and others. We adhere to the clear position of developing scientific research in full accordance with the Antarctic Treaty. I believe that the 30th expedition will write new pages in the annals of cooperation of scientists from various countries.

[Question] And the final question. How many people are preparing for the antarctic winter?

[Answer] The expedition will include 345 people. A third of them have been to Antarctica before. Dmitriy Dmitriyevich Maksutov, an experienced polar explorer, has been chosen to lead the expedition. He spent five winters in Antarctica, has travelled about there, and has flown thousands of kilometers over it. Ryurik Maksimovich Galkin, a no less experienced and competent polar explorer, will be at the head of the winter staff. He has already spent three winters on the sixth continent and about 4 years on ice floes in the Arctic.

All of the participants in the coming trip are now experiencing a very hectic time as the tremendous preparatory work draws to a close. The official beginning of the activity of the new expedition is considered to be the raising of the national flag over Molodezhnaya, the main station. And there is not a great deal of time remaining before this solemn moment.

9746
CSO: 1865/60

ARCTIC SPECIALISTS EXCHANGE IDEAS

Moscow VODNYY TRANSPORT in Russian 4 Aug 84 p 4

[Excerpt] There was a meeting of the collegium of the USSR Goskomgidromet [State Committee for Hydrometeorology and Environmental Control] dedicated to the past work of the wintering members of the 28th SAE [Soviet Antarctic Expedition], the seasonal operations of the following expedition and the tasks of the forthcoming SAE. Participating in the meeting were representatives of the Arctic and Antarctic Scientific Research Institute of the Academy of Sciences, the MMF [Ministry of the Maritime Fleet], Aeroflot, and the USSR Ministry of Geology. The conversation also concerned the extensive geological-geophysical research that is carried out every year during the short summer period in the southern hemisphere. The addresses at the 27th International Geological Congress, opening today in Moscow, will also be dedicated to this work.

The large group of specialists from the scientific-production association Sevmorgeologiya returned to Leningrad from the white continent. In one of its mountainous regions research was carried out in an important division of the program of the 29th SAE. The research was supervised by Vladimir Georgiyevich Shchelovanov, deputy chief of the expedition. He has participated in three expeditions to the distant southern frigid land as well as in 14 "Sever" high-latitude aerial scientific operations in the Arctic. The editor's office of VODNYY TRANSPORT approached him with the request that he comment on the work that has been done. Here is what the scientist related:

Adjoining the Weddell Sea, which is difficult to reach from the navigational point of view, is a huge and still little-known area of the sixth continent. Here, beginning with the 21st SAE, Soviet people established in different years the field bases Druzhnaya at 78 degrees south latitude and Druzhnaya-2 at the base of the Antarctic Peninsula. Last Season, for the ninth time, we continued the overall exploration in a number of places along the coast and in the interior part of western Antarctica.

A deep seismic test of the earth's crust was carried out along a profile extending 320 kilometers. They covered a vast territory with an aeromagnetic survey. They involved themselves with measurements of the structure of the bottom of the southeast zone of the Weddell Sea, with boring through a great thickness of one of the shelf glaciers.... They received a great volume of new and interesting data that made it possible to expand the ideas on the geological structure of the water area of the Weddell Sea and its mountain periphery.

9746
CSO: 1865/61

PARACHUTE EXPEDITION TO ARCTIC

Moscow DAILY REVIEW in English Vol 30, No 131, 29 Jun 84 pp 1-4

[Article by N. Selivanor, candidate of technical sciences, deputy head of Expark-84]

[Text] The idea of the Expark-84 parachute Arctic experiment was suggested by Alexander Sidorenko, head of the group, who is a Merited Master of Sport. The experiment was organized by the USSR State Committee for Hydrometeorology and Environmental Control, and the Voluntary Society for Assisting the Army, Air Force and Navy. Sidorenko has performed thousands of parachute jumps, including a jump onto an ice-capped summit of the Pamirs with landing at an altitude of 7,100 meters for which an award was bestowed on him by the government. The idea was supported by Y. Tolstikov, Hero of the Soviet Union, a well-known polar explorer. With the help of the scientists and experts of the Arctic and Antarctic Institute this idea acquired the clear features of a technique for solution of an acute problem pertaining to the Arctic. Today polar exploration and observations of the changeable behavior of the Arctic are conducted on a large scale. Research teams--meteorologists, hydrologists, geophysicists, physicians and even specialists in auroral displays—conduct research on drifting floes, on islands, in settlements on the coast of the Arctic Ocean. To create normal conditions for their life and work it is essential to build houses, laboratories and power stations. This requires the delivery of numerous materials, equipment and machinery—up to bulldozers and excavators, and then the supply of research stations with food, clothes and fuel.

Of course, the transport problem is acute in the Arctic.

Experts hope that underwater or rather under-ice ships will appear. They will be capable of bringing the cargo, and especially the fuel, which is needed here in great amounts. But so far there are no such vessels. Besides, the problem of unloading these ships, especially if heavy equipment must be unloaded, has not been solved up to now.

That is why aviation remains the main means of carriage and hope of the Arctic. The time-tested AN-2, IL-14 and AN-12 planes, and helicopters on short-haul routes, deliver everything needed by polar explorers. But when a research station has to be set up on a drifting floe, it is precisely aircraft which make this operation long and labor-consuming.

There is no paradox here. Of course, planes fly quickly. But to land on a floe and to take off from it they need a runway. A runway can be made within a short time only if tractors and bulldozers are used. But they cannot be brought if a sufficiently long runway is not made.

To break this vicious circle at first a 400-500 meter runway is made which can receive only light AN-2 planes. They bring polar explorers to a floe, who, using crowbars and spades, begin to lengthen the runway up to 1,000 meters so that heavier IL-14 planes will be able to land on it.

But in the Arctic people cannot exist without fuel. However, the AN-2 cannot bring a lot of fuel during one flight. Because of such a small supply, the number of people to make a runway must be limited, due to which the construction of the runway for the IL-14 is extended to 30-40 days. As for the AN-12 planes, which can deliver tractors and bulldozers, they need a longer--1,500 meter--runway.

These considerations were behind the idea of using parachute technology for establishing research stations on drifting floes. The concept was as follows: ice reconnaissance planes find the proper floe in the ocean and throw onto it a radio beacon, the means for indication of wind direction and force, which are well discernible from the air. Then a group of specially trained parachutists is landed from a heavy transport plane. The first task of this group is to receive cargo and equipment dropped on parachutes a little later and to build storehouses, dwelling-houses, a galley and a diesel station. Then, after actuating technical equipment, the group must quickly make a runway and prepare it for receiving planes with the main staff of winterers. The latter receive all facilities, and the group of parachutists can return to the mainland.

At first sight it may seem that there is nothing out of the usual in this idea: the drop of equipment and cargo from transport planes has been mastered long ago. But the Arctic makes its own corrections in the most usual things, and we must prepare ourselves for any eventuality.

The Arctic lies in high latitudes where the air is highly ionized. This is evident from aurorae glowing in the nocturnal sky. Even a synthetic shirt sparks and sticks to the body when one takes it off in the evening. But how will parachutes made of synthetic material behave? Experts had serious apprehensions that flowing down from parachutes, static charges would do a lot of harm, for instance, burn a hole in the parachute canopy. Fortunately, their apprehensions did not come true.

After preparations and preliminary experiments Expark-84 at last entered its decisive phase: we moved to the Severny Polyus (North Pole)-27 station. We knew that we, parachutists, were awaited there, at the radio beacon by several men landed on the floe from a helicopter—Y. Tikhonov, chief of the future research station, and his first colleagues. That time it was decided to drop at first a tractor and then a platform with fuel. Then our turn came. We,

parachutists, could carry out maneuvers in the air to reach the prescribed landing point. Fourteen men left the IL-76 plane, one by one. Among this group there were a physician, a bulldozer operator, an electric welder and representatives of other professions.

But at that time the tractor was our main concern. Therefore, immediately after landing we rushed to it. There was not a single scratch on the vehicle.

Under the conditions of the experiment the parachuters' ice group had to independently look after itself. It took us a few hours to assemble houses, to heat them and to cook hot meals. After dinner we started preparing the floe for the role of a drifting research station. In particular, we had to help the polar explorers make a runway suitable for the IL-14. The DT-75 tractor fitted with a bulldozer blade helped us cope with the main tasks within just 4 days.

This is a good result—4 days instead of 40 days. But we believe that the main result of the experiment is that the parachute technique of transporting people and heavy cargoes has passed the examination of Arctic conditions. According to preliminary calculations this technique is 2.5-3 times more economical than the existing one since it doesn't need intermediate airfields and other objects. But the main thing is that the winterers, who will be engaged in intensive work on the floe, will not have to make efforts in the construction of the station; they will immediately get into normal conditions.

Obviously parachute technology will be used not only in the Arctic. Take, for instance, the severe sixth continent where research stations of the Vostok type are supplied with all they need by sledge-tractor trains. In such conditions a parachute could become an indispensable assistant of Antarctic winterers.

CSO: 1852/17

29TH ANTARCTIC EXPEDITION CONSTRUCTS NEW ELECTRIC STATION, CONDUCTS RESEARCH, HOSTS INDIAN SCIENTISTS

Moscow IZVESTIYA in Russian 2 Apr 84 p 2

[Article by A. Viktorov: "Radiogram from the Antarctic"]

[Excerpt] Leningrad--At Vostok Station, located at the pole of the cold region, work has unfolded on the construction of a new electric power station. Penetration through the thickness of the ice pack is continuing successfully with the aid of a heat drill apparatus. Unloading of materials has been completed for new construction at Russkaya Station, where an entire construction detachment first wintered. Geologists have conducted research in the shelf glacier region, in the Prince Charles Mountains and in the coastal region of the Weddell Sea.

A group of Indian polar explorers visited the Soviet Novolazarevskaya Station. They are establishing their first station on the sixth continent; the place chosen for it is to the west of Novolazarevskaya.

Preparation has already begun in Leningrad for the new anniversary Soviet Antarctic Expedition, the 30th in succession. Its first ships will set off from Leningrad for the sixth continent in October 1984.

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'MIKHAIL SOMOV' STUDIES ANTARCTIC BOTTOM

Moscow VODNYY TRANSPORT in Russian 7 Apr 84 p 4

[Article by First Mate B. Moiseyev (by radio): "Feverish Activity in the Antarctic"]

> [Text] The flagship of the 29th SAE [Soviet Antarctic Expedition] flotilla is the ice-class diesel-electric ship "Mikhail Somov," which has already been in the southern ocean for more than three months. It continues to fulfill the mission of its ninth voyage in succession to the icy latitudes.

The crew of our scientific expeditionary vessel has already conducted a number of operations in various regions of the Antarctic. When we had completed the ocean crossing begun in the Baltic and entered the Sea of Cosmonauts, a strong and still unbroken seal blocked the way to the chief Soviet South Pole center, Molodezhnaya. Seventy-five miles from it we found a convenient ice field near an anchorage and set to work. Soon we moved toward the edge of the drift ice, where the passenger motor ship "Baykal" was waiting. Two Mi-8 helicopters that we had on board transported 60 future winterers and part of the freight to the scientific city. Having resumed the crossing, we headed for the Sea of Concord. This part of the southern ocean has been explored by Soviet scientists, who have determined it to be separate. It was proposed to distinguish it, beginning in 1964, as a separate sea named in commemoration of the international cooperation of a number of countries in studying the Antarctic.

Along with the liner "Baykal," we visited Prydz Bay. It is famous as the place where giant floating mountains of ice begin their movement north. For 2 days helicopter pilots transported a group of the field party workers and 20 tons of equipment a distance of 200 kilometers from our impoverished harbor into the depths of the White Continent. From the seasonal base Soyuz, established last year near Beaver Lake and the gigantic Lambert Glacier, complex research was accomplished for the second time in the Prince Charles Mountains.

Soviet scientists and seamen conducted a friendly visit to the personnel of the Australian Davis Station. Among those disembarking here were B. Krutskikh, director of the Arctic and Antarctic Institute and N. Tyabin, chief of the 29th SAE. The foreign colleagues cordially welcomed their guests and

familiarized them with the observations being carried out in the area adjacent to Prydz Bay. The meeting took place under cordial conditions and was mutually beneficial.

Then Captain M. Mikhaylov steered the diesel-electric ship toward the Pravda Coast. Often encountered were fields of floe ice and drifting icebergs; sudden blizzards blew over, strong winds whipped up, fog rolled in ... When the "Mikhail Somov" and the "Baykal" arrived at the Davis Sea, it unexpectedly gave them a surpirse. At the height of the Antarctic summer, in the Mirnyy Observatory area, a solid pack, into which was frozen a large accumulation of icebergs, stretched across the vast surface of the water.

Overcoming the obstacles, we moved as close as possible to the oldest Soviet scientific base on the sixth continent. Eight miles from it we cut into ice. Aviators, led by the experienced polar pilot V. Vorob'yev, again raised an "air bridge" between the ships and the continent. During the daylight hours of 6 days, Mi-8 helicopters piloted by S. Rodionov and M. Khrenov transported a large landing party of new Antarctic settlers and almost 300 tons of assorted freight, including containers of instruments and a good deal of provisions.

While the helicopter crews were resting, we were breaking through the heavy ice pack toward Tokareva Island on the Mirnyy route. In places the thickness of the ice reached two meters and more. In addition it was viscous and thickly covered with snow. In a watch we sometimes gained little more than one cable length. Captain M. Mikhaylov, his second in command, V. Rodchenko and the remaining navigation officers, the chief mechanic, V. Ovsyannikov, and all the seamen had to apply their knowledge and work experience in ice with complete efficiency in order to approach the island and successfully unload heavy ground transport equipment onto it. Continuing to break through the pack, we reached Stroiteley Island, where we replenished the helicopter fuel supply from a coastal reservoir.

Many thousands of miles were left behind, travelled in the high southern latitudes. Having completed the work at the Pravda Coast, we took a course toward New Zealand. After a short stop in the port of Wellington the Diesel-electric ship "Mikhail Somov" returned to the snow-covered land. The participants in the voyage, headed by N. Tyabin, and candidate of geographical sciences, chief of the 29th SAE, were faced with new operations. The first of them took place at the Soviet Russkaya and Leningradskaya Stations, situated in almost inaccessible places on the Antarctic coast.

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NOTES ON OPERATIONS

Moscow PRAVDA in Russian 4 Apr 84 p 6

[Article by Pravda correspondent V. Bardin: "Where Winter is at the Threshold"]

[Excerpt] Antarctica--A windless sunny day at this time of year is a gift to the Antarctic. And the polar explorers are hurrying to make use of it sensibly. Oceanologist Gennadiy Kadachigov is conducting a dive beneath the ice. He is studying the evolutionary process of the underwater part of coastal glaciers and firns, to the edges of which ships are usually moored.

Today's dive is one of the final ones of this season. Kadachigov observes changes in the underwater part of the glacier, measures the temperature, and photographs various objects. Two hours of work in the cold water is not an easy task. But the researcher is collected and calm.

Roman Panchugin, candidate of geographical sciences, chief of the aerometeorological detachment, informs us of the approach of the next cyclone. In recent years, thanks to the launching of artificial satellites, weather prediction has become significantly more precise. The space apparatus makes possible the observation of the drifting of sea ice and icebergs.

Among those who winter at Molodezhnaya many know the local conditions well. Chief of the geophysical team Yuriy Ivanov, engineers Anatoliy Zenin and Nikolay Orlov, chief of the airstrip detachment Grigoriy Kabatov, and engineer-mechanic Valeriy Velichko are not in the Antarctic for the first time. Others, for example chief of missile atmospheric sounding Anatoliy Yanochkin, have worked in the Arctic. So the novices have someone to learn from.

Right now Cuban and Mongolian scientists are at Molodezhnaya. The Molodezhnaya radio detachment, headed by experienced radio operator Vyacheslav Rusakov, tries to have no one feel isolated from the motherland. Radio transmitters ensure communication with the cities of our country, and also with Havana and Ulan-Bator.

Every week the chief of the wintering personnel, Lev Bulatov, conducts a dispatching meeting. Right now, at the threshold of winter, there is a great deal of business. The housekeeping of the station requires constant attention. The severe environment does not tolerate omissions. And because of this they are working in the Antarctic without days off. The diesel-electric ship "Kapitan Gotskiy" and the motor ship "Baykal" have arrived in the Molodezhnaya region. The main loading-unloading operations are forthcoming...

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